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AN IDEAL COURSE IN BIOLOGY FOR THE HIGH SCHOOL.

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The ideal course in biology for the high school is bound to be full of difficulties for the teacher, but the object of the present discussion, as I understand it, is not so much to relieve the teacher of the burden he has assumed as to smooth the way for the pupil so that the energies of the latter may be more profitably distributed than at present. Consequently it is the pupil we should have in mind while planning an ideal course rather than the personal preferences of teachers or what the colleges would like to have done in a preliminary way to their candidates for admission.

It should be remembered that only a relatively small percentage of secondary pupils reach the college or university. To the great majority of boys and girls the high school, if not the grades, marks the end of school days, and thus any course of study to be ideal, plainly should minister to this majority while at the same time providing suitable preparation and advancement to those who are fortunate enough to go on. For this reason the high school course in biology should be general in its scope. Let us attempt to throw open the windows of the soul in many directions and so create as large horizon as possible for the pupil. Teach principles and ideas; teach methods of seeing and of interpreting what is seen; teach how to study things rather than facts about things; teach how to be an intelligent citizen in a world of life. It is the high calling of the teacher of biology in secondary schools to leave the pupil like a well-planted garden which is bound to develop naturally in after years into a thing of beauty and a joy forever, rather than like a hot-house in which a few selected plants have been forced artificially into premature bloom.

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Thus a pupil should emerge from an ideal course in biology with comprehensive ideas about living things and their more general relations, which will form a suitable background or setting for the acquisitions of after life. He should appreciate the value of a biological fact and know how to place it in his general scheme of things, but he does not need to have collected a very large store of facts. Above all things he should never be blasted with the notion that he has *finished* biology, but he should retain, or have kindled within him, a lively, abiding interest in the world of life which surrounds him that shall ensure his continued growth. Plutarch has said: "The soul is not a vase to be filled but rather a hearth to be made to glow."

How is such an ideal to be attained?

The plan I have to propose is brought forward for discussion with much hesitation, since a ten years' apprenticeship as a high school biology teacher in the strenuous and progressive city of Chicago has placed me in a position to appreciate the imperfections of any such plan, yet I feel confident that it offers on the whole a better means of attaining our object than the plan I last employed or the plans, so far as I know them, which are now in prevalent use. Before presenting this outline, however, it may be well to point out two of the pitfalls which it is intended to avoid.

First: *The danger of allowing the laboratory to assume too important a role.* The laboratory method was such an emancipation from the old-time bookish slavery of pre-laboratory days that we may have been inclined to overdo it and to subject ourselves to a new slavery. It should never be forgotten that the laboratory is simply a means to the end—that the dominant thing should be a consistent chain of ideas which the laboratory may serve to elucidate. When, however, the laboratory assumes the first place and other phases of the course are made explanatory to it, we have taken, in my mind, an attitude fundamentally wrong. The question is, not *what types* may be taken up in the laboratory to be fitted into the general scheme afterwards, but *what ideas* are most worth while to be worked out and developed in the laboratory, if that happens to be the best way of doing it, or if not, some other way to be adopted with perfect freedom. Too often our study of an animal or a plant takes the easiest rather than the most illuminating path. What is easier, for instance, particularly with large classes of restless pupils who

apparently need to be kept in a condition of uniform occupation, than to kill a supply of animals, preferably as near alike as possible, and set the pupils to work drawing the dead remains? This method is usually supplemented by a series of questions concerning the remains which are sure to keep the pupil busy a while longer, perhaps until the bell strikes, and which usually are so planned as to anticipate any ideas that might naturally crop up in the pupil's mind during the drawing exercise. Such an abuse of the laboratory idea is all wrong and should be avoided. The ideal laboratory ought to be a retreat for rainy days; a substitute for out of doors; a clearing house for ideas brought in from the outside. Any course in biology which can be confined within four walls, even if these be the walls of a modern, well-equipped biological laboratory, is in some measure a failure. Living things to be appreciated and correctly interpreted must be seen and studied in the open where they will be encountered throughout life. *The place where an animal or plant is found is just as important a characteristic as its shape or function.* Impossible field excursions with large classes within school hours, which only bring confusion to inflexible school programs, are not necessary to accomplish this result. Pupils can be aroused without hardship to do their best biological study outside of school hours. This is particularly true of bird study. However, it is far from my intention to minimize laboratory work. Properly administered it is without doubt one of our most efficient devices for developing biological ideas, but the laboratory should be kept in its proper relation to the other means at our disposal and never be allowed to degenerate either into a place for vacuous drawing exercises or a biological morgue where dead remains are viewed.

Second: *The danger of over-emphasizing the Type-Study Method.* When the revolt came against teaching biology by authority out of books, the other extreme found expression in the method of Louis Agassiz, who, as you remember, is reported to have isolated for days an uninitiated pupil with a pickled fish in a doubtful state of preservation and the sole direction: "Study the fish." This method was felt to be too vague and impracticable to produce good results except in the hands of genius. The type-study method was, therefore, brought forward, a method consisting in a succession of studies upon an approved series of forms in which certain orthodox observations could be repeated and confirmed by the pupil with the aid of definite directions.

Huxley's was the master mind that initiated this method, and the old Huxley and Martin laboratory manual with its list of classic types has proved to be the sturdy ancestor of a large and varied line of descendants in the way of laboratory guides all dominated by the same idea. The original manual appeared at a time when the evolution of the forms of life was the dominant biological conception and when it seemed of the highest importance to make a morphological survey of the entire animate creation. The only possible method of covering so extensive and diversified a field in any manner whatsoever was plainly to select representative examples of the world's population and to establish these as standards by which all others could be measured. The Huxley and Martin scheme was originally designed for college students, who afterwards as disciples and teachers carried the idea to the secondary schools. Too often, therefore, the secondary course became simply a dilute decoction of the original college brew, with the result that frequently the pupil went to college only to encounter again the same old galaxy of sainted types—amœba, hydra, earthworm, starfish, crayfish, clam, and frog—which he thought he had already disposed of in the high school. The living universe has thus come to be a rather limited affair, a sort of oligarchy of a few forms invested with an extraordinary significance, and any chance organism outside these Brahmin "types" comes to occupy an unimportant position in the pupil's mind and to assume somewhat the abnormal features of a freak.

Another danger of the type-study method is that once begun it seems of the utmost importance to complete a particular series of types, and difficulties sometimes arise in attempting to compress all this into a fixed school program. Furthermore, needless repetition of methods and ideas is likely to follow in the similar treatment of successive types, while the opportunity of retaining the pupil's interest is lost. Since the subject matter in biological science is so varied and extensive it would seem to be an unpardonable waste of resources to be confined year after year to the same classic series of types. Is it not possible to do your duty by your pupil without, for instance, impressing him with the fundamental importance of the earthworm as the morphological corner stone on which all bilateral animals have been builded? I know it is heresy not to "do" the earthworm. Against the animal itself I have no prejudice. As a matter of fact I admire immensely its possibilities. Indeed, there are very

good reasons for the selection of each of the sainted types, but has not the time now arrived when we can enlarge our conception of the relative importance of the forms of life about us and break free from the dominance of a single line of approach in our study of living organisms? The repetition in our study of types may be compared to the arrangement of things in most museums, in which as many specimens as possible are on exhibition in a given space. The newer conception of what a public museum should be, as is being worked out in the American Museum of Natural History in New York City, for example, is to utilize every inch of space not for the display of as many different specimens or types as possible, but rather for the presentation of ideas. The Esquimau room, for example, is no longer made up of numerous glass cases crowded with Arctic paraphernalia to the certain confusion of the ordinary observer, but rather a few well-chosen groups of life-sized models representing Esquimaux in various phases of daily activity. From such a room one comes away with a definite picture in mind of what Esquimau life is like.

But leaving the discussion of the dangers of overdoing type-study and set laboratory exercises, the promised plan of study I am here to advocate divides the subject matter not as usual, into botany and zoölogy, but into, first, THE DEPENDENCE OF LIVING THINGS UPON THEIR SURROUNDINGS, and, second, THE COMPARATIVE STRUCTURE AND FUNCTIONS OF ORGANISMS.

For the first half of the year, then, according to this scheme the dominant idea is:

The dependence of living things upon their surroundings. Perhaps the word Ecology comes as near as any other single word to defining what is meant. At any rate it is a dynamic point of view—an attempt at a rational explanation of the living world as we find it in operation around us. In order to do this it is not a necessary prerequisite that the entire animate creation be reviewed through the study of various types. It is not necessary to acquire beforehand a very large technical vocabulary. Names of things will be forthcoming naturally enough when there is need for them. The procedure with the animal or plant will not be, kill it, name it, draw it; but rather, what does it do? How does it do it? How did it come to be doing this where it is? I realize that there are difficulties in successfully treating environmental studies with large classes within laboratory

limitations, but the difficulties are by no means insurmountable and great rewards surely await pioneers in this field.

The following arrangement of subject matter for the first half year is suggested in part by a plan given by Professor Karl Kraepelin of Hamburg in *An Introduction to Biology* just published (Einführung in die Biologie, Teubner, 1909). It should be said, however, that Professor Kraepelin is in no way responsible for what follows.

The work in the first half, then, may be divided into eight general topics, the first four of which are to be devoted more particularly to plant and the last four to animal life, minimizing so far as possible the barrier that has been erected by technical science between the two cognate fields of zoölogy and botany. Of late years there seems to be a tendency to do this very thing. Biologists are coming to deal more and more with ideas about living things, and less and less with animals and plants as such. Professor Bateson in England, for example, is no longer to be reckoned simply as a zoölogist. He is now a student of heredity, dealing as readily with sweet peas as with rabbits, and any organism, be it animal or plant, that furnishes material for his central idea, he utilizes with equal facility.

TOPIC I, PLANTS IN THEIR PHYSIO-CHEMICAL RELATIONS. Under this heading may be grouped the effect of heat, light, gravity and such physical factors upon the existence of plant life; the adaptations of vegetation to frost on the one hand and to desert heat on the other; the optimum temperature for different plants; the effect of sudden changes of temperature; the adaptability of plants through acclimatization to new conditions; the display of green surfaces in the struggle for light; the adaptations of plants to various light intensities and to changes in intensity; the effect of the succession of day and night and in general the great role of chlorophyll in nature. Furthermore, the relation of plants to surrounding media, such as the soil, air and moisture, are subjects easily lending themselves to laboratory experimentation when the problems involved are once understood and clearly outlined. It is worth while to propose biological problems for the pupils to work out in the laboratory or outside in their own way. It does no harm if the piece of work cannot be completed within a single laboratory period or if the pupil has to start a second thing before the first is completed. Life is full of incompleteness. It is, moreover, a mis-

take for the teacher to monopolize all the fun of invention and discovery. A surprising degree of ingenuity and resourcefulness will come to the surface if interest is once aroused and the pupils are given a chance, a fact brought very forcibly to my own mind by an incident that occurred while I was teaching in Chicago. In a certain text-book we were using with rather soporific results, reference was made to the fact that deep-sea temperatures are ascertained by using a thermometer that records the temperature whenever it is reversed. The question arose, how can a thermometer be turned upside down at any desired level under water. The thing puzzled me, I will confess, and to gain time I resorted to a pedagogical device of which I do not have the exclusive copyright, by saying, "Oh, that is easy! It won't do you any good for me to tell you. Think up a scheme that will work and demonstrate it to the class to-morrow." The next day three different models, constructed out of pieces of string, lead pencils, erasers and various other schoolroom wreckage were brought in and displayed. These models immediately fired the imagination of the beholders and those who had not contributed asked for an extension of time. On the third day we had 47 different devices hanging from the gas fixtures in the laboratory, contributed by about 125 pupils, and a halt was called when, finally, one boy, who had never displayed any particular interest in his work up to that time, demonstrated with a jar of water to represent the ocean and a nail upon a wire to symbolize the thermometer, a device in which the reversal was brought about by the contact of two poles of a home-made battery held at the surface. It is appalling to imagine what the result would have been if those pupils instead of being to a large extent of foreign parentage, had been real, genuine New England Yankees!

Topic 2, The Distribution of Plants, is, in general, an outdoor subject. It may be subdivided into, first: the distribution of plants in the form of plant societies, as, for instance, the forest, the meadow, the pasture, the marsh, the roadside, the pond or the vacant city lot; and second: the distribution of plants in larger aspects, i. e., the great zones of vegetation as they occur from arctic to tropic latitudes extending from the poles to the equator, or in altitude from the base to the summit of mountains. The parallel between distribution in latitude and altitude may be worked out successfully in a very limited area

without the knowledge which comes from extensive travel or books although there is no reason for ignoring these sources of information as some extreme adherents of the laboratory method apparently would have us do. For example, the distribution of organisms at the seashore upon a sea wall exposed to tidal changes will be found upon close examination to be very definite and for each species surprisingly uniform. If now a neighboring salt marsh with a sloping beach be critically examined these same organisms will be found arranged in the same relative positions not only with reference to each other but also to high and low water marks just as if the sea wall had been tipped over and stretched out flat. Here, of course, the dominant factor in determining distribution is moisture while in the general disposition of the great zones of vegetation in latitude and altitude temperature probably plays the more important part, yet the principle is the same in both cases.

Topic 3. The Relation of Plants to Each Other, subdivides into, first: the relation of the sexes which may be briefly developed from an evolutionary standpoint without technical details and without the objections which arise in some minds against emphasizing the very important theory of sex upon animals; second: the relation of parents to offspring, i. e., the provision which parents make towards giving their offspring a suitable start in life and the devices with which they are provided for securing a distribution of their seeds; third: the competition between plants both of the same kind and of different species, for standing room, for light, for the opportunity of completing their life story successfully, etc., and fourth: the ways in which plants make use of each other, as climbing plants and epiphytes, which stand upon the shoulders of other plants without necessarily causing them injury; symbionts, which live in relations of mutual helpfulness to each other, and parasites, which show how one plant obtains the upper hand of the other and seizes the spoils of the victor.

(To be continued.)

A FIRST COURSE IN ZOOLOGY.

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It is no easy task to arrange an entirely satisfactory elementary course in any science subject, and in no subject are the difficulties greater than in zoölogy. There are so many fundamentally important aspects to the science that it is hard to determine what may and what may not be omitted, where the emphasis should be laid, what should be the viewpoint, and what the aim of the course.

Indeed, we can scarcely have a single viewpoint in a beginning course without sacrificing that breadth of vision which gives one a good grasp on the subject. The instructor is therefore compelled to shift from time to time the point of vision in order to preserve the proper balance in the course. It will help us to a correct aim if we remember that the course should be made for the student, and that the student is not necessarily to be made for the college or university. As I conceive it, the aim may be expressed thus: the life of the student on the highest possible plane of intelligence and culture to which zoölogy can lift it.

Much of what the student will get out of a course depends on the impressions received from first contact. Whatever is the action, its reaction will bear a close relation to it. We profit from study in direct proportion to the interest we bring to it, to the effort we put into it. Live interest is generated most readily in direct contact with living nature, and the current is maintained without difficulty and without loss so long as this contact is maintained. Of course, many important forms of animal life cannot be kept in living condition; but if living forms are kept in breeding cages or aquaria in the laboratory, the interest in the whole animal world is easily maintained, even in the presence of preserved marine or locally unobtainable land forms. The river mussel, crayfish, fishes, water bugs and beetles, earthworms, snails and many kinds of insects, are easily kept for observation and prove a never failing source of interest.

If the course which I am about to outline seems to contain too much matter, let me urge that the time for playing at science in the secondary school is past. It is useless to expect to secure results at all worth the expenditure of the time in less than a solid year of faithful work, with double periods of laboratory

work more than once during the week. Prolonged and careful observations are necessary to a successful course in zoölogy. Moreover, it is far better to master one science thoroughly than to have scarcely a respectable speaking acquaintance with six. Unless the year's work can be made thorough, it had better not be offered at all.

In order to secure immediate interest, the course may well begin with those common forms which are found at nearly all times and places, insects, birds, and anything else that may present itself. Some instructors exclude the insects from the beginning courses because they happen to have a course in entomology later. This, and any similar omission, is a serious mistake. Should a student who can never have more than one course in zoölogy be denied a knowledge of the most common, most varied, and most interesting group of the whole animal series? All the types should be included in the first year if possible.

There need be no haste in the use of the microscope, especially the compound one. Too often it is a mere machine thrust between the student and nature. The magnifier has its legitimate use, and is a necessary instrument; but it can easily be made a hindrance rather than a help in the first weeks when direct hand to hand contact with nature means so much in the development of interest.

In studying the living forms, habits are of prime importance. The methods of locomotion, the nature of the food and methods of obtaining it, the securing of oxygen, methods of defense, nesting and egg laying habits, etc., suggest themselves as subjects for painstaking observation. And this work leads as naturally as possible to the study of life histories. Material is easily secured and kept, especially in the case of butterflies, moths, chrysomelid beetles, mosquitoes, flies, crickets, grasshoppers, etc., and a few typical examples of complete metamorphosis will give the student a better idea of the succession of generations than volumes of reading could do.

These studies lead to a consideration of the larger relations: the ecological aspect of zoölogy is extremely interesting and offers unlimited material from which to select. The relation of the animal to its environment—air, water, soil, light, temperature, food supply—through structural adaptation and instinctive habits, the interrelations of animals and plants, habits

of hibernation, local distribution, etc., are subjects which stimulate thought and active original investigation.

In this broader consideration of the relations of animal life, we find the point of contact with the life of man; and the economic side of zoölogy may well receive its emphasis here. This subject should not be made a one-sided one. We are interested not only in the enemies to agriculture, and the producers of discomfort and disease, but also in those forms that are valuable to man in various ways. The coccinellidae, the ichneumon flies, and nearly all birds are of inestimable value. The earthworm in its humble way contributes largely to the productiveness of the soil. The sponges of commerce, the mollusc, which yields the pearl, the pearl buttons, and the crushed shell for the poultry yard, the lobster and the crab, the silkworm and the honey bee, are only a few of the thousands of animals useful to mankind. On the other hand such forms as phylloxera, the cabbage worm, the cotton boll weevil, chinch bug, army worm, potato beetle, cut worm, tobacco moth, etc., illustrate abundantly the destructiveness of insect pests. The mosquito and the common house-fly afford examples of disease carrying forms. The economic discussion should not stop short of the methods of preservation of the friends, and control of the enemies of agriculture.

At some point in the course the student must be introduced to some of the fundamental conceptions regarding structure. As good a place as can be found for this is just preceding a study of the general morphology of the series of animal types. The structure of cells, both typical and specialized, should be carefully worked out, and some knowledge of how cells reproduce by division to form tissues and organs is necessary to a clear understanding of life and growth. Other general physiological processes in cell life should be discussed, and the process of fertilization and reproduction should be gone over again and again as each form is studied, until the mystery of new life is mastered.

This perfect understanding of the processes of reproduction in all animals and plants as secured in mixed classes of boys and girls, young men and young women, by the repeated study of that process in the lower forms, is of the very highest moral and ethical significance. This one aspect gives to zoölogy and botany their strongest claim to high rank as cultural studies.

This feature alone makes the teaching of zoölogy and botany in the secondary schools and colleges a fundamental necessity.

After a broad survey of the whole field such as is suggested above, the best results have been obtained in my own experience by a study of the general morphology of types. In the first year course greater attention is given to external features than to the internal. Especially are those structures noticed which enable one to determine at sight in what group of animals the specimen in hand should be placed. The internal dissections should deal with those larger, more easily observed series of organs, such as the digestive tract, the central nervous system of the larger forms, and certain features of the musculature and skeleton if the latter exists. The circulatory system in the higher forms is worthy of study.

I am convinced that in the long run the best results are obtained by presenting the types in ascending order of development whenever that order is well established. And no types should be omitted if they can be readily obtained. A brief resumé of the forms found most useful is given.

Protozoa can be secured from hay infusions at all times. Grantia and the bath sponge are good for the Porifera, and should be followed with a hydroid or hydra, a jelly fish, sea anemone, and coral, as examples of the coelenterata.

Nothing is gained by creating a heterogeneous group known as vermes. The names Platyhelminthes, Nemathelminthes, and Trochelminthes are unfortunate, but it is easy from the start for the student to recognize flat worms, round worms, and rotifers, if specimens are actually observed. Planaria and the tape worm, Ascaris and Trichina, and various rotifers can be secured easily. The echinoderms and molluscs are not well located in the series, but follow the low worms as well as any other group. The starfish and sea urchin, the bivalve mussel and Helix are sufficient for these groups.

The earthworm or Nereis may be used as a type of the annelid worms; and, after this group, the Arthropods should receive considerable attention. The myriapod, crayfish, butterfly, house-fly, beetle, etc., can be used. Lastly a mammalian vertebrate should be dissected as carefully and fully as possible. Good drawings and accurate descriptions must be required throughout the course in order to make the work effective.

This may seem like a formidable list of forms to be presented

in a first year course, but, if time enough is given, it can be done successfully with excellent results. Naturally the work is not to be attempted on the same scale as in the college or university. Many a teacher fails in the secondary school by attempting to transplant a college course into secondary school soil. It never works well. The amount of work done should be adapted to the age and capabilities of the students, to the number of hours allowed for the course, and to the facilities. This adaptation calls for keen judgment on the part of the instructor. But I believe the adaptation is best brought about by doing genuine secondary school work on a goodly number of forms, rather than by attempting to do college work on only a few types.

The latter method of study teaches the student something of the *methods* of zoölogy, but as a rule he knows surprisingly little about zoölogy at the end of the course. I do not mean to say that there is no value in the intensive work on a few forms, but I do question seriously whether it is a good course for the student who can have but a single year in this science.

One feature which ought to be brought out very clearly and simply even in a first course, is the fact that evolution has been and still is taking place. I use the term evolution in its broadest sense. The conception of a developing universe is at once the grandest conception and the most fundamental truth which the human mind has ever grasped. The theory of descent is now merely one of method. The plain, simple fact is as easy to demonstrate as that the square on the hypothenuse is equal to the sum of the squares on the two bases of a right angled triangle. The few cases on record in which evolution has been actually observed, coupled with the certain knowledge that the animals which live on the earth a million ages from now must come from those that now exist, and with the just as certain knowledge that those now existing are the direct descendants of animals of past ages, unlike the present forms as is shown by their fossil remains, make the fact easily grasped and understood.

This is not the place for many theories regarding the how and the why of development. We need not be mutationists, nor natural selectionists, nor orthogenesists, nor isolationists, nor need we tie ourselves to any isms. But evolution itself is now considered one of the certainties of modern science. It is accepted as a fact by every man who is competent to judge by

reason of having studied the evidence, however much he may differ from others as to the method or the cause.

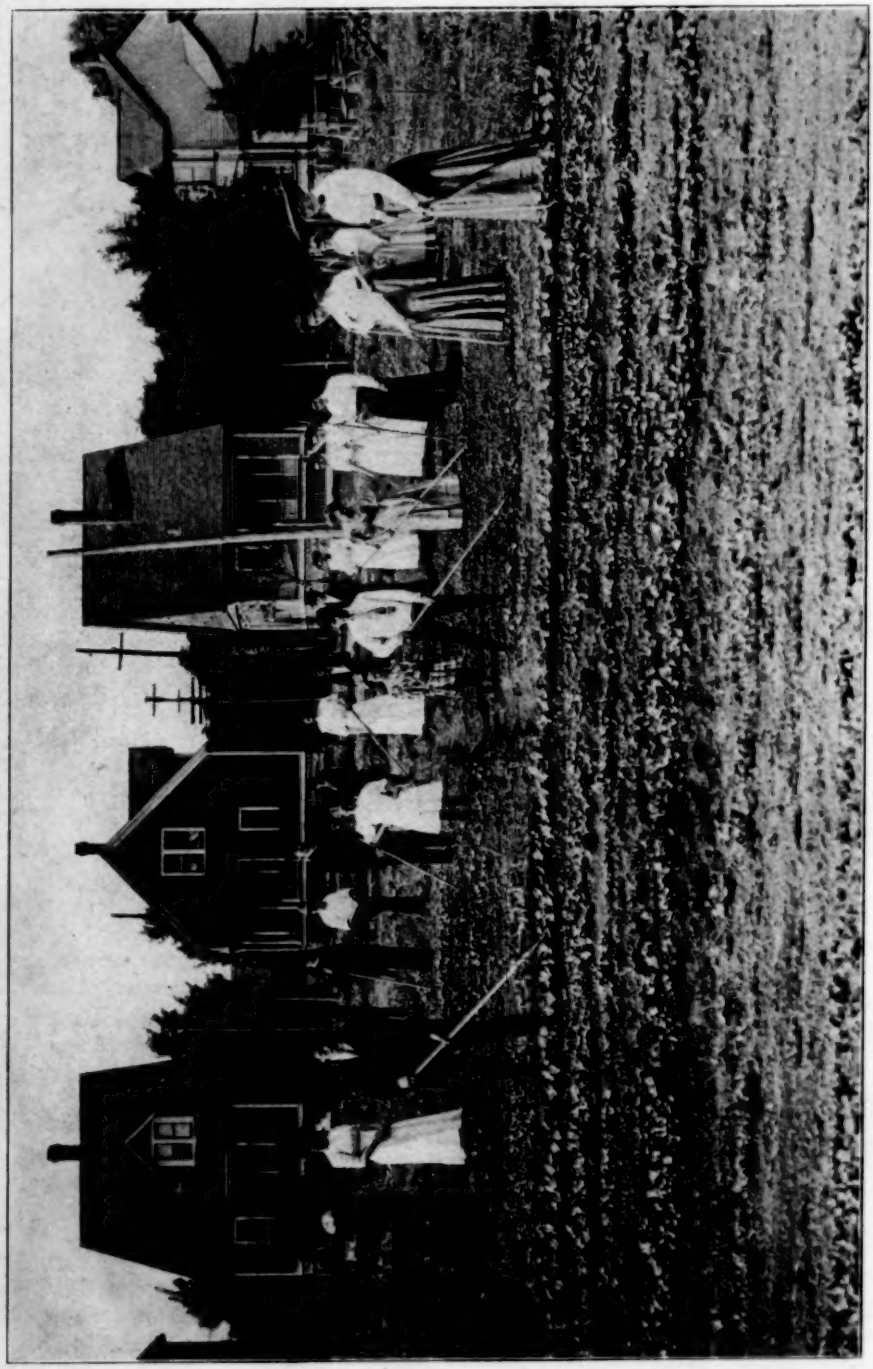
Sooner or later the adjustment of one's ideas to this conception must be made, and it can be made more readily and more naturally when the mind is plastic than later, and without disturbing the springs of moral action. It is my firm belief that the recognition of the truth of evolution forms the best possible background for the development of lofty intellectual, moral, and spiritual life.

It is hoped that this brief discussion of a first year in zoölogy may lead to further discussion or suggestion. The historical development of a science is always exceedingly interesting, and if good libraries are at hand, readings in the lives of the pioneers afford a very valuable kind of supplementary work. The course as outlined can be presented in a year's time, and will give, I believe, a well-rounded basis for the understanding of familiar biological phenomena, and for the full enjoyment of this interesting field of nature. At the same time it provides an adequate introduction to the college courses, so that if the student possesses the natural aptitude and desire for zoölogical study, he can continue it into the larger fields, where he may take his place as a coworker with those who are making the conquest of knowledge and truth.

WHAT ONE CLASS IN AGRONOMY DID.

To begin with, it was not down on the list of high school studies and the outlook for a class was anything but promising. The school had no land that could be used for a garden and the laboratories were filled with other classes, but there were several energetic students in school who wanted to put their botany to a practical test and their repeated entreaties finally won the day; the superintendent consented to the course and the botany teacher agreed to teach it. At the beginning grave doubts were expressed as to the desirability of such a course. Now, as we review the season's work, all are agreed that it has been one of the most useful, most instructive and most enjoyable of the courses given in the school. The word enjoyable is used advisedly. There seems to be no reason why a pupil should not enjoy his studies. The fact that he usually does not is no indication that this is the proper state of affairs. But let that pass. This is to be a brief account of the lines of investigation pursued and the difficulties surmounted that resulted in a satisfactory half year's work. Anyone interested in going deeper into the subject can obtain a complete syllabus by applying to the editor of this magazine.

The first difficulty encountered was in the selection of a proper text. The school is a city school and the teacher was well aware that it would not do to try to teach city children how to plow, milk, thresh or cultivate field crops. But all the books that could be found either took the opposite view or were too elementary for pupils who had already completed a year's work in botany. There was nothing left to do but to make a book of their own. Fortunately the library of the teacher was well equipped with the reports of the United States Department of Agriculture and the various Agricultural Experiment Stations in addition to the usual texts in botany and agriculture, so the theoretical part of the work was soon selected. Keeping in mind the needs of the class, it was decided to direct the greatest attention to such operations as would enable city pupils to more intelligently care for their gardens, lawns, shade trees and flowering plants. The name of the course was therefore changed from agriculture to agronomy, it being understood that agriculture relates to all the business of the farm, while agronomy has to do simply with plant production, though the dictionary does not exactly bear out this distinction. The course



THE CLASS AT WORK.

was planned to begin in February and cover the second half of the school year, with most of the theoretical work coming early in the course when the weather would be too inclement to permit of work outdoors. Class work consisted of lectures and explanations by the teacher and the laboratory work of experiments performed by the pupils, all of which were properly written up in individual notebooks.

The study of the origin and composition of soils was first to occupy the attention of the class. Field-trips were made to characteristic deposits of sand, clay, gravel, peat, marl and humus and specimens brought in for various experiments in the laboratory. Typical garden soils and subsoils were also tested as to their composition, porosity, capillarity, etc. This naturally led to the question of the dependence of the plant upon the soil, fertilizers and their sources, alkaline and acid soils and the effects of adding lime and humus to soils. The requirements of the plant with reference to heat, light and moisture were largely matters of review, but more time was spent upon such subjects as the effects of tillage, drainage, mulches, frost and rain, together with acclimatization and resistant varieties.

By this time various indications of spring turned the thoughts of the class to garden-making. A thorough discussion was given to the subjects of planting, cultivating and crop rotation, after which each pupil was directed to ascertain the average size of a city lot and plot it on a scale of a quarter of an inch to the foot. In the meantime the teacher had obtained from a well-known seedsman a copy of his spring catalogue for each pupil. With this as a text the class was required to plan the garden for growing not less than fifteen different kinds of vegetables indicating the proper methods of planting and the correct distances apart. The amount of seed needed was estimated and each pupil made up an order for the necessary seeds exactly as if ordering seeds for a real garden. About this time the newspapers became interested and aided the general movement for better gardens by publishing the best plans made by the class.

Gardening on paper, however, did not satisfy the pupils. Lacking land for their purpose near the school, a vacant lot some distance away was borrowed and plans were made for a real garden. Sufficient gardening tools were purchased by the school, but there were other expenses to be met, such as

fencing, plowing, etc. These latter the pupils themselves took care of, electing a treasurer and contributing enough funds to settle all bills. Incidentally this drew the attention of the class to plowing and harrowing, fence posts and their proper spacing and the cost and advantages of various kinds of fencing wire. The garden was large enough to give to each pupil a plot six by twenty-five feet for his own. The soil was deep and rich but it had been covered with a tough blue-grass sod; and many in the class were girls. Nevertheless they "fell to" and in spite of blistered hands soon reduced the sod to subjection. It may be said in passing that right in the midst of operations the owner of the lot had a chance to sell it, but the teacher, not to have his plans upset in any such way, bought the lot and it will now be used for as many agronomy classes as need it.

Through the kindness of their congressman, the class received enough seeds for the garden. As soon as the early planting was finished, attention was given to lawns and lawn making, terracing, planting, mowing, etc. Then the planting of shrubbery and perennial flowering plants was taken up and the rules for correct planting discussed. Field trips for the study of the best examples in the parks and private grounds were made until the pupils could distinguish the good from the bad planting and give reasons for their selection. Each pupil was then required to make a plan drawn to scale for the decorative planting of a city lawn. In this they were assisted by the illustrated catalogues of two dealers in decorative plants, which were sent for the purpose. The best of these plans were also published in the newspapers. On Arbor Day one side of the garden reserved for shrubbery and flowers was planted with groups of specimens dug by the pupils from wild lands in the vicinity.

The subject of pruning followed planting. After a discussion of the subject the trees along the streets were visited and the good and bad work singled out. Pupils were urged to trim their own plants and even some of the girls either did this work themselves or superintended the efforts of father or brothers. While the crops were growing there were a series of lectures and discussions on such subjects as plant propagation, plant breeding, diseases, insect pests and remedies, etc. The greatest interest, however, centered in the garden. As often as necessary, time from the regular school day was devoted to its cultivation and the work was carried on exactly as if in a laboratory in

school. No attempt was made to keep track of the amount of vegetables raised but all the pupils kept their home tables supplied, while several sold their surplus for sums ranging from twenty-five cents to two dollars. The crops found most desirable to grow, because they will mature before school closes, are spinach, lettuce, radishes, cress, beets and onion sets. Beans are worth planting if only for their rapid and lusty growth, but if planted early are likely to give a crop. In addition to the few standard crops that all were required to plant, the garden boasted of thirty-two different kinds of vegetables. Among these were several of the rarer species that previously had been known to the pupils only by name, such as oyster plant, artichokes, endive, chard, rape, cow peas and kohl-rabi. Twenty-eight kinds of flowers were also grown. These were restricted to the borders of the grass plot and a strip fronting the shrubbery.

When school closed, the connection of the class with the garden was supposed to end, but it was decided that those who wished might continue their gardens through the summer, and several did so. The other plots were placed in charge of two pupils for the rest of the season with the understanding that if properly taken care of they should have an extra credit at the end of the year. These pupils immediately cleared the ground and planted corn, tomatoes, cabbage, celery, turnips and winter radishes so that all the ground has yielded two crops and some of it, three. As this is written an asparagus bed is being made and rhubarb and berry bushes set out. A large number of spring flowering bulbs have been ordered for the border and it is expected that the beginning botany classes will use these in their work on flowers next spring. From the beginning the garden has been a great attraction, not only to the parents of the pupils directly concerned but to the public at large. Although not on the main line of travel, scarcely a day has passed without one or more visitors. In consequence there has been a noticeable improvement in the appearance of many gardens and lawns throughout the city. The class started with a membership of twenty. Five of these were graduated last June and of these latter two have gone to college to take courses in forestry and agriculture and two others are teaching. In this vicinity we are strong for agronomy.

C. N. W.

MOUNTING PAPER MAPS ON MUSLIN.

FRANK CARNEY,

Denison University.

The different bureaus of the government are issuing annually a large number of maps that might be used more generally in our schools. Nearly all of these maps, however, are printed on paper. No kind of paper when much handled is very enduring. All such maps, then, should be mounted on muslin if we wish to get the best service out of them. In this article I will describe briefly a method of mounting paper maps.

The muslin should be stretched on a flat surface; I use a table made purposely for the work. It has a pine top, 6½ by 10½ feet, and 1¾ inches thick. The boards are sawed with a special locking joint and glued together. The top is not fastened directly to the base but is held by bent iron plates attached to the under surface of the top and fitted into grooves in the base; this allows the top to shrink and expand with atmospheric changes without checking and warping as would be the case if it were screwed or nailed directly. While such a map-mounting table is very satisfactory, part of the expense which it represents adds only to convenience in the work. Very good results may be had in using even a kitchen table in case you do not wish to make assembled maps larger than this form of table. I frequently combine numerous separate sheets into one large one, and for this work a commodious table is sometimes necessary. Even a table of the above dimensions can be made for less money, and at the same time answer most purposes; the top may be built up of thinner boards laid crosswise so as to prevent warping, and putty used if cracks develop. Such a top need not be fastened at all to the base, but simply set upon it. Soft wood should be used; otherwise it will be difficult to fasten the muslin with the thumb tacks.

In nearly all maps there is some margin of plain paper which may be dispensed with when mounting; for this reason, I trim the maps as closely as possible. The size is thus reduced for housing, at the same time saving muslin. For trimming the sheets I have a zinc-covered platform 21 by 28 inches; this is made of two courses of boards to insure a level surface. It may be placed on a table when in use. A shoemaker's knife drawn along the edge of a square gives the best results; it is absolutely necessary in making assembled maps that the trimming

be clean-cut. A piece of plate glass large enough to hold a carpenter's square is even more satisfactory than the zinc-covered platform.

The maps should be moistened thoroughly before mounting; this is best done by placing them face down to a flat surface, and spreading the water with a brush, a cloth, or the hand; several maps may be moistened at once. It will be necessary to lift the map occasionally to keep it free of wrinkles, as the map gets larger in taking up the moisture. Some maps will require more time for this part of the process than others; this is due to a variation in weight of the paper on which the maps are printed.

Before applying the paste, all surplus water should be wiped off with a cloth or sponge; this is necessary in order not to dilute the paste. I use what is generally known as book binders' paste. The following formula will mount about one hundred topographic sheets: mix three fourths pound of flour with one pint of cold water; stir this slowly into two and one half quarts of boiling water, and add one teaspoonful of powdered alum. This should be strained through a coarse cloth, and allowed to cool before using. It is very necessary that the paste be spread uniformly over the whole surface of the map, and care should be taken particularly near the edges; I use a two inch, fine bristle brush for this purpose. In placing the map on the muslin always avoid lifting by the very edge; reach back a ways from the edge; the film of paste is partly removed wherever the fingers touch. Care should be taken to spread the maps smoothly on the muslin; this is generally best accomplished by spreading out from the center toward the ends.

In making combined maps of adjacent topographic sheets, it is advisable to first arrange them in the proper positions and then to proceed with the trimming. Commencing with the sheet at any corner, the bordering side and end should be left untrimmed; the other side and end should be trimmed leaving a margin about one fourth inch wide; the next adjacent sheet to the right or left should be cut along the meridian line; a margin should be left on its opposite side and on one end; when ends are to be matched, one will be trimmed along the parallel. In this way the highways and contour lines can generally be made to match. If in a set of sheets that you wish to combine into a single map the paper should vary much in weight, it will be necessary to allow the thicker sheets more time for taking up

the moisture. If when you come to paste these to the muslin it appears that a particular sheet does not match readily, by a little manipulation you will be able to stretch it; or, if necessary, it may be laid down without any stretching, and even allowed to shrink some. In spite of all care, however, some instances arise in combining maps when it is found impossible to make the highways and contours always continuous.

The topographic maps of the United States Geological Survey are used more extensively than any other government maps; but the sheets accompanying Water Supply Bulletins, as well as those issued by other branches of the Survey, may be used to advantage in our teaching; the maps issued by the Bureau of Soils of the Department of Agriculture are also of much value.

The combined maps may be rolled on a piece of moulding for storing. Any map cabinet, or other fairly dust-free enclosure, will answer for storage purposes. If many combined maps are to be used in a school, much time can be saved, and the life of the map lengthened, by keeping them in a specially constructed cabinet. For housing single sheets any method that keeps them free of dust and convenient to get at is satisfactory.* If a school should accumulate many hundred topographic sheets, the question of storage becomes one of much concern, because a teacher should have them so conveniently arranged that the minimum amount of time is required for putting his hand on any particular map.

The use of the topographic sheets is largely limited to high school classes in Physical Geography. In some schools, not many, however, they have been profitably placed in the hands of grammar and grade pupils. Personally, I feel that a child who is mature enough to get anything out of a map in his geography text-book will be profited by a topographic map. Home geography especially may be advantageously approached through the local sheet; the child is easily interested in a map that gives details with which he is familiar.

At the present time, the topographic survey of Ohio has covered about eighty per cent of its area. Within a very few years maps for the whole state will have been issued. Typical areas of the state illustrating several phases of relief, as well as many of the economic relations between physiography and industry are now available. The extent and the manner in which this material might profitably be used may be discussed in a later issue.

*In the *Journal of Geography*, Vol. VII, pp. 52-54, 1908, I have described and illustrated cabinets for both rolled maps and single sheets.

CHEMISTRY AND CULTURE.*

By Lewis B. Avery,

Principal San Jose High School, Cal.

At the Berkeley meeting I made a plea before this body for a cultural course in physics to be as nearly as possible for all pupils in the third year of the high school, those desiring preparation for the technical courses of the university being allowed to take thereafter the ordinary course in physics, it being argued that by such an arrangement a much larger number of students would obtain a knowledge of physics and those taking the more technical course would find in it great profit because of this preparation.

While I have not the test of experience to commend a similar course in chemistry, I believe it to be as feasible and as necessary and for similar reasons. The present course does not attract young people as largely as it should. During the last eleven years, according to the last report of the Commissioner of Education the percentage of students in high schools taking chemistry has dropped from 8.95 per cent to 6.52 per cent, notwithstanding the increase of facilities. I want to recommend what I should consider a cultural course in chemistry.

Chemistry and physics readily separate themselves from the other sciences. Huxley classes botany, zoölogy, geology and astronomy as biological sciences. They all are embodiments of an evolutionary and self-determining process, that whether it be considered in the simplest plant or in the solar system, may be called a life process. Such a science has an essential unity growing out of the unity of the life that it embodies and discloses—a discernible purpose which gives it a dignity apart from any considerations of human interests.

Physics and chemistry, on the other hand, treat of the laws that nature applies in all these life sciences, separate from such application.

Nature is an exposition of the biological sciences, and the biologist, if he is a seer, consciously unites with the poet in linking together natural processes into one "tremendous whole." But no such harmonious principle of internal life binds together the subjects of physics and chemistry.

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*Read before the Pacific Coast Association of chemistry and physics teachers at San Jose, December 31, 1908.

No one disputes the cultural value of astronomy, unless he view it merely as a mathematical science. Changing our viewpoint from the consideration of the life sciences to a consideration of the laws under which they operate, is much like stepping from the audience and getting behind the scenes to investigate the machinery of the stage. Fairyland at once ceases. The rainbow loses its pot of gold. The philosopher's stone ceases to inspire. Any organization of physics and chemistry from an internal point of view deals largely with mathematics and with abstruse theory, but culture must take hold on life. The term culture is more or less indefinable. A classical education has been supposed to do something towards conferring it and doubtless does very much. It is an exposition of human life.

The subject of chemistry in the high school is well presented and well taught from the scientific point of view and is endeavoring, where possible, to lay hold upon human interests. The most recent text-books bring prominently into view the endeavor to make the science of human interest by calling attention, where possible, to the illustrations of the science in nature and its application in the arts and manufactures. It is a ragged endeavor to link chemistry with the world of nature and the world of men. In so far as it goes it is cultural in its effect, but it is so overweighed by the technical side of the subject and the organization of the subject is so evidently independent of these applications and illustrations that chemistry must be considered as a long ways from a truly cultural subject and has little place in a strictly cultural course.

It is my own belief that the subject of elementary chemistry should as clearly evince the progress of the race out of the rule of superstition into the rule of science as does the subject of history show the emancipation of man from the powers of darkness in political and religious thought. Literature and history, dealing with the aspirations and accomplishments of men, have always been highly valued as instruments of culture. Yet chemistry may be so presented as to show mankind, through its agency, growing out of the darkness of alchemy and the philosopher's stone into the radiant power of to-day, clothed as it is with the finest garments of theory, but still enveloped in mysteries more penetrating than those of former days; conferring upon mankind powers beyond the conception of the alchemist, but with more munificent favors ready to bestow upon the disciple of to-day; transforming the meanest of materials into the

necessaries and luxuries of life. If chemistry can be viewed from the standpoint of historical development and its service to mankind rather than from that of chemical theory and preparation for technical schools, there is no doubt that it would become one of the most cultural of the sciences inspiring within the youth who study it, respect for its dignity and power, admiration for the wonders it performs, and an inspiration for its future.

Such a preliminary course is to-day marked out by no textbook and would have to be given largely by the teacher who himself desired to see the work successful, but once inaugurated such a course would be sought and should be taken by all and would be the best of preparation for a strictly technical treatment along the lines of to-day's chemistry.

The high school is for all the people and not the picked few and what we give should be calculated to reach all the people, to enlighten the community, to help them to discern science from pseudo-science and to make them intellectual readers of the popular scientific literature of the day, interested in the developments and applications of science without being superstitious in regard to them. Shall we leave the large percentage of our high school people untouched by the knowledge of chemistry for the sake of the few who are to take technical courses in the universities? Would even these be hindered—would they not rather be helped—by a more vital presentation of the subject? Is it not required of the science people of to-day that they shall see that the department which makes the largest claims upon the public treasury shall meet the needs of the entire community in so far as possible, and that chemistry, as a view of the laws of matter, shall be preceded and illuminated by a view of chemistry as the emancipation of the race from the thraldom of superstition? Instead of insisting upon formulas and mathematics and quantitative work, would it not be worth while for our young people first to see visions that shall make the drudgery of investigation worth while in their eyes?

In closing, let me say that I am not pleading for less chemistry, but more chemistry and better. For a chemistry that shall not place less emphasis on the manufacture of powder and soap and window glass nor even upon ionization and other theories, but more weight upon the interest and culture of boys and girls and of men and women. Just as the music in our schools

is taught not for the purpose of creating artists in the line of music, but for the creation of a public with music in their souls so that they can appreciate good music, and just as literature is taught in our schools not primarily for the purpose of creating poets and litterateurs, but for the purpose of creating a public that shall understand and appreciate literature and be able to respond to the inspiration of it, so chemistry should be taught primarily not for the purpose of making chemists, but of creating a public intelligence regarding chemistry. Such a policy in the lines of music does not discourage but magnifies musical art. With regard to literature, writers are not decreased in number but rather increased and inspired by the enthusiasm thus created, and so, cultural courses in chemistry and the other sciences that shall be able to reach the public generally will not tend to decrease or discourage the creation of experts and specialists in chemistry, but rather to discover and inspire a larger number to delve into the secrets of nature.

Whatever may be thought of the necessity for such a course as I have outlined, I think no one can deny that scientific education in a scientific age should be made to reach the masses of the people in some way, and that it does not do so at the present time seems to me painfully evident.

WHY BODE'S LAW? No. 2.

In No. 1, page 150 of the February, 1909, issue of this Journal it is shown that a planet or satellite, supposed to be formed from a parent nebula would tend to form openings .63 and .48 of its own distance from its primary.

Now rejecting all theories "that planetary systems have had their origin in a cooling and shrinking nebular mass," let us suppose two planets or satellites captured by Lee's theory or formed in whatever way one may choose, only holding to Dr. Lee's hypothesis that they are revolving in a nebular resisting medium, then the outer body will tend to produce openings in this medium at distances .63 and .48 of its own from its primary. The resistance of the medium tends to push the inner body into these openings. If at the same time this body tends to capture the medium between the openings, it will tend to have a mean distance a little over one half that of its companion next without. Other modifying causes will act and one should expect those planets nearest the sun to have shorter, and those most remote, longer distances than this law would give for the intermediate bodies. We should also expect this method of arrangement to hold for the satellites of Jupiter, as it does.

T. M. Blakslee, Ames, Iowa.

IONIZATION THEORY. DEMONSTRATION WITH APPLICATION TO ELECTROLYSIS.

(Continued from the October issue.)

By Harry A. Carpenter,
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The practical interest is in the relation between ionization and electrolysis. I think it ought to be made clear that, except in a very few cases, ionization precedes and is independent of electrolysis. Electrolysis is the process of sorting the ions to their respective poles and thus making the separation more or less permanent. It must also be kept in mind that, while solution in water, methyl alcohol and other solvents is the most common cause of electrolytic dissociation, heat and to a limited extent electrical energy cause electrolytic dissociation, as for example, the fused hydroxides of sodium or potassium. Also, ions of solution may be formed in various ways. They may be the simple molecule ionized into simple ions, complex ions due to the interaction of ions and ions, or ions and molecules.

In conducting an electrolysis the question whether the liberated product is a primary or secondary product is important, as it has been determined that metals deposited as secondary products give a finer grain, more compact, durable and shiny coating than when the same metal is deposited as a primary product. In most cases the current strength and voltage are determining factors. In the electrolysis of dilute solutions of strong acids and bases it is probable that the hydrogen and oxygen are primary products. In the electrolysis with a weak current of dilute hydrochloric acid the products are hydrogen and oxygen as primary products due to the slight ionization of water. A stronger current with higher voltage may give some chlorine as a primary product at the positive pole due to the slow ionization of water molecules, while with a weaker current time is given for new molecules of water to dissociate. With concentrated hydrochloric acid and a strong current hydrogen and chlorine are evolved as primary products. In the electrolysis of salts of metals that decompose water, hydrogen and oxygen are liberated as primary products if the current is weak, while with a stronger current and higher voltage the metal is probably deposited first and then reacts with water forming hydrogen as a secondary product. In the electrolysis of water the hydrogen and oxygen

are probably primary results. Pure water has a very small conductivity, therefore water is to a very slight extent dissociated into hydrogen cathions and hydroxyl anions. An acid is usually added to increase the conductivity. The acid, sulphuric for example, ionizes into hydrogen cathions and sulphate anions. The cathions of the acid migrate toward the cathode, take the place of the cathions of the ionized water molecules, which have given up their charge to the cathode and separated from the solution as ordinary hydrogen. The sulphate anions migrate toward the anode to take the place of the hydroxyl anions of the water which have given up their charges to the anode and reacted with water to form water and oxygen which is liberated as a gas. In the electrolysis of salts of the harder metals, copper, gold, silver, nickel, etc., the anion usually takes the same procedure as the anion of sulphuric acid. The metal cathion is usually deposited as a primary product from simple salts but as a secondary product from double salts, hence the use of double salts in electroplating.

In every case of electrolysis a certain decomposition voltage must be used to cause the ions to migrate and become discharged. In the case of acids, bases and salts of alkali metals, if hydrogen and oxygen are the primary results, the decomposition voltage is practically the same and, as we have seen above, it should be so since it is really the decomposition voltage of the dissociated water molecule. In the case of salts of the harder metals the decomposition voltage varies with the cathion and on this fact depends the electrolytic separation of metals. If salts of two metals, A and B, are in solution and if A has a decomposition voltage of 1.7 and B of 1.8 then so long as the current has a voltage more than 1.7 and less than 1.8 only A will be deposited. After A is all deposited the current may be raised a little over 1.8 when B will deposit. If the voltage is more than 1.8 in the first place, both A and B will deposit simultaneously and in a proportion controlled by the current strength and composition of the electrolyte. Advantage is taken of this fact in brass plating, the cathions being copper and zinc. If the voltage is less than the decomposition voltage of that salt in the solution having the lowest value, the current will be interrupted, hence it is evident that a certain amount of electrical energy must be expended to cause a definite migration of ions and a certain potential difference between the ion and electrode must exist to cause the ion to deposit or become discharged.

The use of the theory of ionization in explanation of the action of indicators, neutralization and hydrolysis is important. Litmus is a weak acid and as such is only slightly, if any, ionized in water. The color of the molecule is red and in the presence of a solution of a strong acid no ionization of the litmus takes place and the color of the mixture of solutions is red due to the red litmus molecule. With a solution of a strong base the weak acid litmus reacts with the base to form a metal salt of the litmus, which dissociates into the metal cathion and litmus anion which is blue. This reaction takes place only if the metal is combined originally with an hydroxyl ion which unites with the hydrogen cathion of the litmus acid to form undissociated water molecules. Litmus cannot be used to advantage with weak bases, i. e., those that are slightly dissociated in water, because a salt of a weak base would be formed with the litmus which would hydrolize the water to produce the original condition again to a certain extent and prevent a sharp color change. Practically the same explanation applies to the weak acid phenolphthalein. The following experiment is given by Jones to illustrate the action of indicators. An alcoholic solution of phenolphthalein is colorless since the molecule is colorless and is not dissociated in alcohol. If alcohol is in considerable excess a few drops of strong ammonia may be added without the red color of the anion of the salt of phenolphthalein being evident. The explanation is that ammonia is but slightly dissociated in alcohol, hence the substances, I should say, act as a weak acid and base and no color change is seen. The addition of water will dissociate the ammonium hydroxide when, as a strong base, it reacts with the phenolphthalein acid to form a dissociated salt of phenolphthalein which has the red ion. This explanation has been contested by Professor Hildebrand of the University of Pennsylvania in the December number, 1908, of the *Journal of the American Chemical Society*. With sodium or potassium hydroxide instead of ammonium hydroxide the color reaction occurs normally since they are dissociated in alcohol. Certain it is that the reactions of indicators are not well understood and furnish good material for investigation.

An acid may be defined as a substance that ionizes in water into an electro-positive hydrogen ion and electro-negative, non-metallic ion; and not as some present day text-books say, that an acid is any substance whose water solution gives free hy-

drogen ions, for as we shall see a water solution of copper sulphate gives an acid reaction due to hydrolysis. Hence, a distinction should be made between the terms "acid" and "acid reaction." A base is a substance that ionizes in water into an electro-positive ion and electro-negative (OH) hydroxyl. All acids in solution give the hydrogen cathions and all bases in solution give the hydroxyl anions.

Since water is but slightly dissociated, whenever a mixture of solutions is made so that free hydrogen ions and hydroxyl ions are in the same solution, they unite to form molecules of undissociated water. Hence we have the explanation of neutralization; for example,

$$NaOH + HCl = NaCl + H_2O \text{ (undissociated)}$$

Therefore the heat of neutralization is really the heat of formation of the hydrogen ion with an hydroxyl ion, and is constant for solutions of all strong acids and bases. Reactions between weak acids and bases depend on the fact that the water molecule is less strongly dissociated than the acid and base molecules. Also the heat of neutralization is somewhat less than that of strong acids and bases.

Hydrolysis, the reverse of neutralization, depends upon the fact that weak acids and bases are but slightly dissociated, if at all, in water and that water is dissociated to a slight extent and may be considered either as a weak acid or weak base, HOH. A strong salt of a weak base, for example, copper sulphate, dissociates in water into copper cathions and sulphate anions. If then there are a few dissociated water molecules we have also in solution some hydrogen cathions and hydroxyl anions. But copper hydroxide is a weak base, therefore some of the copper cathions unite with the few hydroxyl anions of the water to form undissociated copper hydroxide, thus—

$$CuSO_4 + 2HOH = H_2SO_4 + Cu(OH)_2 \text{ (undissociated)}$$

which leaves an excess of a few hydrogen ions and these give the acid reaction. Likewise with strong salts of weak acids, some of the anions of the salts unite with the few hydrogen ions of the dissociated water to form a few molecules of undissociated acid. For example, sodium carbonate is a strong salt of the weak acid carbonic, and the reaction may be represented thus—

$$Na_2CO_3 + 2HOH = 2NaOH + H_2CO_3 \text{ (undissociated)}$$

This leaves an excess of a few hydroxyl ions which give the alkaline reaction. Copper and zinc form weak bases; hence,

solutions of salts of copper and zinc give acid instead of neutral reactions. Sodium carbonate and potassium cyanide form weak acids; hence, solutions of their salts give alkaline reactions.

Some interesting facts in connection with the theory of ionization I can only mention. It ought to be understood that the term ionization is not synonymous with the term dissociation, but with the phrase electrolytic dissociation, which means that the dissociated parts are charged, while the term dissociation refers to a separation into parts that are not considered to be electrically charged.

The electro-static charge on a gram equivalent ion is 96,500 coulombs and shows why ions cannot be separated by osmosis as can the products of ordinary dissociation.

Chemical action seems to be most rapid between ions, hence strong acids, bases and salts are more active chemically than the weak, i. e., organic substances. It is even claimed and on good evidence that chemical action can only take place after ionization and only so fast as ions are formed.

Dry sulphur or phosphorus will not burn in dry oxygen.

Dry sulphuric acid and hydrochloric acid have no action on litmus and will not react with dry carbonates.

Dry ammonium gas and dry hydrochloric acid will not react.

Dry hydrogen and oxygen will not unite even at a temperature of 500° C.

The catalytic action of acids in causing inversion of cane sugar seems to be due only to the hydrogen ion.

The fluorescence of solutions is probably due to dissociation.

The theory of ionization is far-reaching and offers great possibilities to the investigator.

Those who wish to study this subject more in detail are referred to the following:

Text-book of Electro-Chemistry by Arrhenius.
Elements of Physical Chemistry by Jones.
Modern Theory of Solution by Jones.
Physical Chemistry by Ostwald.
Theory of Solution by Whetham.

SYMPOSIUM ON THE PURPOSE AND ORGANIZATION OF CHEMISTRY TEACHING IN SECONDARY SCHOOLS.

(Continued from October, 1909.)

The Requirements of a First Course in Chemistry.

VIII. By W. A. Noyes,

University of Illinois.

Four things are to be gained in a first course in chemistry: First, a knowledge of the fundamental theories and principles of chemistry and the ability to understand the language and to apply the theories and principles of the science; second, a knowledge of some of the facts which are most important in their relation to the theories and principles of the science and also of facts which are important in relation to the experiences of daily life; third, skill and accuracy in laboratory manipulation and in observation, together with ability to interpret and record properly the observations made; fourth, some knowledge of the historical development of chemistry and of science in general and an appreciation of the fact that all of our scientific knowledge is fragmentary and is rapidly increasing.

The total acquisition of the pupil in each of these directions will vary greatly with the maturity and ability of the students but the relative importance of each is essentially the same in the secondary school as in the college or university. Nor is the question whether the student is to continue the subject further, or not, of much importance in deciding what or how much shall be given. This will depend chiefly on the maturity of the pupils and the time which can be allotted to the subject.

A knowledge of fundamental theories and principles is placed first in importance, but ought not, of course, to come first in time. Theories should always be presented in the closest possible connection with facts and it is necessary to come back to this relation over and over again and to make clear that a theory is of value in proportion to the accuracy and completeness with which it can interpret the facts. But while fact is always the supreme arbiter it ought not to be forgotten that theories and fundamental principles are more important and useful. A student might learn the density of a hundred gases but it would be much better worth his while to learn how to derive the density from the formula of the gas. Illustrations of this sort might be multiplied indefinitely. If it were not for those few simple

theories and principles which run like threads of gold through the almost infinite number of complex facts with which we deal in chemistry any real knowledge of the subject would be wholly impossible.

What has been said with regard to the importance of theories and principles should guide us largely in the selection of the facts which are to be presented. Chemistry has for us such a vast array of information which is important in its bearing on questions of daily life and it is so much easier to hold the interest of students for such information and so much easier to acquire it than it is for them to master the processes of reasoning required for a thorough grasp of theoretical principles that there is an almost irresistible temptation to give too much prominence to this side of the work. One of the greatest faults of our present day education all the way from the grades to the graduate school of the university is that we are giving our students *information* rather than *power*. After we have got beyond a few common things like respiration, combustion, fermentation and the like, the chance that we shall impart to the student those particular bits of information which will be directly useful to him afterward is very remote. But if he can acquire the language of chemistry so that he will understand the information which is to be found and above all if he can acquire the power to reason from and apply the information which he has, faculties of the mind will have been trained which it is far more important to cultivate than the memory. I do not mean that no attention should be paid to the practical importance of the facts presented. Other things being equal facts about common things should always be chosen rather than others, but mere information is not the main purpose of the study. The teacher who does not awaken some interest in the great fundamental truths of nature apart from their practical bearing has largely failed.

It is also very important indeed that facts should be learned in their logical relationships and not each independently by a mere feat of memory. Equations should never be learned by rote but always reasoned out from the fewest possible data, and many illustrations might be given of how a fact may be derived partly, or entirely, from others already known. We should watch carefully for such relations and use them whenever possible.

The importance of the laboratory work is universally recog-

nized. Care, accuracy, and neatness must be secured, of course. The student should write his notes in the laboratory and should be required to write clear and correct English and to select for record the things which are really important. Most important of all is the attitude of the student toward the work. It should not be considered as a set task to be performed but as a means of acquiring all of the knowledge possible about the substances with which the student is working. A logical, systematic development of principles in connection with the experiments should be secured, if possible, rather than a disjointed set of experiments to give information. It is at this point that the first course presents the greatest difficulty in the laboratory and I do not think that any laboratory manual has altogether solved this problem. It is a very general experience that students take a much greater interest in qualitative analysis than in laboratory work in general chemistry. I do not think this is altogether or chiefly because they think, mistakenly, that the work is more practical. It is rather because there is a logical, systematic scheme of analysis and unknown substances present themselves as problems to be solved. Also because the operations of analysis are reviewed by repetition till they make a more permanent impression.

There are many reasons why some historical setting for the study of chemistry is very desirable. The story of the discovery of oxygen by Priestly, of the composition of air by Lavoisier, of the alkali metals by Sir Humphrey Davy, of argon by Rayleigh, of artificial diamonds by Moissan may be presented in such a way as to be intensely interesting and so as to give a clear notion of how our science has grown and is growing to-day. An account of the development of LeBlanc, of Solvay and of electrolytic soda will help the student to understand and appreciate the revolutions which are constantly occurring in chemical manufacture and some of those forces which have completely transformed the conditions of human life during a single century. It may be objected that this is history and political economy and not chemistry, and that is partly true but they serve wonderfully well to illuminate and fix in the mind the chemical facts to which they are related and they are a part of that broader knowledge to which every student of chemistry has a right. I know nothing better than the history of the great achievements of the past to inspire with noble ideals the chosen few upon whom we must depend for further achievements in our science.

SCIENTIFIC AND MATHEMATICAL TEACHING IN THE FUTURE.

By Fredus N. Peters,

Kansas City, Mo.

The scientist believes absolutely in the truth of the laws of the Conservation of Mass and of Energy. Indeed, it is probable that the human mind is so constituted that these laws are really axiomatic. But when we see every form of energy being constantly changed into heat and as rapidly dissipated, without appreciably affecting the temperature of boundless space: when we see upon the outskirts of every town and city countless thousands of unsightly, so-called tin cans, rapidly undergoing disintegration: when we see iron in all its forms—wire, broken castings, and the like, much of which never falls into the hands of the rag man, wasting away and in a few months disappearing into the soil we are convinced that although the conservation of matter and energy is true, the dissipation of both is equally an absolute certainty.

We have all read of, if we have not experienced, the discomforts of the heat and dust of subway travel in New York. But we may not know that 61.3% of this dust is simply fine iron particles worn from the brake shoes as they are used to stop the cars. By actual record kept by those in charge of the repair department of this railway system one ton of brake shoes is ground up every month per mile of subway. To a lesser degree the rails and wheels are likewise being ground to dust. In this way twenty-five tons of steel every month in this subway is ground to powder and disappears. This process in a measure is going on all over the world and in the aggregate the loss is enormous.

The output of pig iron for 1906 amounted to nearly twenty-five and one-half million tons. This means that this campus would be covered with a block of solid iron two hundred feet in thickness: if all the blast furnaces of the United States were combined in one, it would be more than five times as high as the Eiffel tower; the greatest of the Egyptian pyramids would not reach even to the blast pipes that carry the air in at the base of the furnace; the coke used in this furnace would if placed in

*Presidential address delivered before the fifth annual meeting of the Missouri Society of Teachers of Mathematics and Science at Columbia, Mo., May 1, 1909.

one pile make a column considerably over a mile high and about one and a third city blocks each way at the base; the sheet iron which is marketed every year would cover nearly two thirds of Boone County; the cut nails if put into one properly proportioned would reach beyond the summit of Washington monument and the wire nails would make one five and one-half feet in diameter and as high as the Eiffel tower; if the steel rails from our rolling mills were combined into one, that one would be eighty-one feet wide at the base, twenty-one feet high, one and one third miles long and wide enough at the top for one of our large freight engines with tender attached to rest crosswise, with considerable room to spare even then.

Much of this enormous output is being used where it will be protected yet vast quantities are exposed to the elements and are surely and rapidly going back to the form of oxide in which men found it; but with this exception, that, while before, it was stored up in great deposits, now it is dissipated beyond all recovery.

What is true of iron is even to a greater extent of tin. In the past forty years the output has increased about five hundred per cent and has reached considerably over one hundred thousand tons per annum. Of this the greater portion is employed in the preparation of solder and for so-called tin cans. When they have once served their purpose their fate is that of becoming an eye-sore, until the disintegrating action of atmospheric oxygen has mercifully hidden them in the soil of the earth never again to be gathered together.

As with these metals, so with lead, zinc, and various others. Enormous increases in output have been made in the last twenty-five years, while the same methods of dissipation are rapidly proceeding. It means that unless new storehouses are discovered, the present supplies will be largely exhausted in the next half century. What man could do without them is a question which at present would be impossible to answer.

It is not the mineral kingdom alone which is thus rapidly being depleted. For some years our more far-sighted statesmen have been calling attention to the prodigal use of our forests. In 1899 we used in America something less than two million cords of wood in making paper pulp, while last year the amount was almost four million. The paper used by our great city dailies is enormous, some of the larger ones requiring about ten acres of

forests for every one of the 365 days of the year. In the same way the hard wood forests of the North are being swept away to supply the demand for charcoal, wood alcohol, pure cider vinegar (?), acetic acid, and other by-products, while the yellow pines of the South are disappearing as rapidly in the production of turpentine and allied products.

We may be prepared to accept the above but it is difficult to believe that such little things as matches and spools are assisting materially in the rapid destruction of our forests. It is said by good authority that the United States uses one and one-half million matches every minute of the twenty-four hours of the day, 2,160 million matches per day. This is as many as all the rest of the civilized world together and serves to illustrate a characteristic of the American people. Seven hundred billion matches a year means 225 million feet of the best lumber—not the scraps from some great planing mill, but the very best the forests can give.

Last year three of the New England States made 1,600 million spools, Maine alone using over 7,000 cords for this purpose; about as much more was used for these small barrels for our retail confectioners: lead pencils last year used 7,300,000 cubic feet of cedar, while the hard wood sawed for veneering, 330,000,000 board feet, was sufficient to completely cover half of almost any Missouri county. So dozens of little things, which add greatly to our daily comfort and to which we scarcely give a thought, are rapidly consuming our once magnificent forests.

In the same way, with perhaps even greater disregard for the future, our agricultural population has ravaged the soil. Year after year they have removed the crops which nature has so bountifully furnished and have returned almost nothing.

What does all this mean? Simply this, that for these sins of extravagance we shall most surely have to pay. Many of the problems which confront us are of our own making, and with reasonable care could have been postponed to a distant future; as it is, not so. It seems a dreadful waste that we should be so rapidly consuming the vast deposits of coal kept so perfectly for us through the ages and yet being unable to secure more than five to ten per cent of the total energy contained therein. In all these years since the invention of the steam engine with its various modifications in form and increase in size we have come little nearer the solution of the problem of getting more than a

small per cent of the energy contained in the coal. We are proud of the ocean liners which are now crossing the Atlantic weekly in four to five days, but we have little conception of the enormous cost of the coal used by their powerful engines.

It is a somber picture; has it no high lights? I would answer, "Yes." We have not sinned away altogether as yet our rich heritage. It is possible that some of our legacies we have scarcely touched. There is one metal which in many ways is perhaps fitted to supplant iron. Aluminum constitutes over 8% of the earth's crust, about twice that of iron, and far more accessible. But no method has been devised as yet for extracting this metal from the abundant deposits. It seems entirely probable, however, that the secret of unlocking this great storehouse will some day be discovered and the wonderful treasures be given to the world. It is true that at present aluminum could not take the place of steel on account of being lacking in tensile strength, but undoubtedly methods of alloying it with other metals will be discovered and this present difficulty be removed.

As a substitute will probably thus be found for iron and steel, so undoubtedly the disappearance of our forests and the consequent scarcity of lumber will bring forth some substitute possibly even more efficient for building purposes. We are familiar with the growth of the cement industry and know that it with steel is practically supplanting the use of wood in our large modern buildings. In 1906 our cement factories marketed over fifty-one million barrels, about five times what was used ten years before. If the ideas of Edison as advanced in recent months are adopted cement will very largely supplant wood in dwelling houses as well as in large public buildings.

Before our coal beds are exhausted possibly other means of generating power will have been discovered. In the last few years we have begun to realize that our streams may be made to turn our dynamos and undoubtedly great advancement will be made in this direction; but what we shall do for power upon the sea cannot as yet be foretold.

Perhaps the greatest problems must be worked out along agricultural lines. Will there be any means of restoring or maintaining the fertility of soils? Some fifty years ago the first synthesis of an organic compound was made—that of urea—from so-called inorganic substances. It removed barriers hitherto supposed impassable and led to the hope that possibly all or-

ganic compounds might some day be thus obtained. If urea, a compound of nitrogen, carbon, hydrogen and oxygen, could be prepared synthetically, why not sugar and flour and starch? So the enthusiast began to believe that the day would come when the chemist would displace the farmer and by some easy process, in the secrets of his private laboratory, he would combine the hydrogen and oxygen of water with carbon from some other source, and starch or sugar or some similar carbohydrates would be readily furnished. Alas! Such dreams like many others of our waking moments are probably destined never to be fulfilled. In fact the sober-minded chemist has ceased to dream such dreams. Here is one plant breathing in the carbon dioxide of the air, absorbing moisture through its rootlets, combining the two in some wonderful way to form starch; another growing under the same sunshine converts this same water and carbon dioxide into sugar; others store up in their fruit from these same two things one acid or another, malic, oxalic, or tartaric, which as the process of ripening goes on are all converted largely into sugar.

Here is another plant which combining with these same substances the nitrogen found in the soil prepares the proteids necessary for the upbuilding of animal tissue; another using the same materials, working in the same laboratory under the same beneficent sunshine, converts these same subtances into such deadly alkaloids as strychnine and opium. The chemical processes of nature are wonderful beyond all conception and it is probable that we shall never be able in this way to synthesize many of the food products of the world. The problems of the chemist lie along other lines.

We are all aware of the fact that our atmosphere is about four fifths nitrogen; someone has estimated that there are in the air about ten million billion pounds of this gas. Chemists have been accustomed to dismiss this tremendous quantity of inert matter with the statement that almost its sole purpose is to dilute the oxygen of the air and thus render it suitable for respiration. Such a theory does not seem at all in harmony with the plans of an all-wise Creator. Why should he have made an atmosphere of oxygen five times as rich as man's lungs are able to use and then have created such an immense amount of otherwise useless material simply to dilute this oxygen? The idea is not sensible nor tenable.

For years this same Creator has been hinting to us a possible use for this nitrogen but we have been slow to perceive it. It has long been known that during violent thunder storms certain oxides of nitrogen are produced which combining with the rain form nitric acid. Occasionally this is in sufficient quantities to yield chemical tests. Notwithstanding these hints it is only recently that any serious attempts have been made with promises of success of combining these two gases of the atmosphere by electrical processes and furnishing a fertilizer to the agriculturist.

Another very wonderful success has been made in recent years by the scientist. I refer to something familiar to all, the inoculation of legumes with nitrogen-fixing bacteria. Here again we have discovered a means of drawing upon this inexhaustible storehouse from which most plants have little or no power of gaining their needed nitrogen and through these bacteria not only furnishing sustenance to the growing crops themselves but storing it up for others in the future. Thus one of the three essentials for plant growth and the one most expensively obtained seems within reasonable reach. The other two necessaries, potash and phosphate, are not found abundantly anywhere. There was a time when one of the chief sources of pearl ash was wood ashes and thousands of acres of great forests are said to have been burned solely for the potash they would furnish. Now, two other sources are yielding considerable quantities—one, suint, the natural oil upon wool, which contains from fifteen to thirty-three per cent of potassium carbonate; the other the pulp from the sugar beet. Much of western Kansas and eastern Colorado land is alkaline in character not suited to the production of other crops. The beet has the power of abstracting this potash from the soil and thus not only furnishes a valuable by-product but at the same time is gradually fitting the soil for the production of other crops. But even these sources are quite limited and the problem of fertilizers cannot be accepted as settled.

These are but a few of the difficulties which we must meet in the near future? Shall we be equal to the demands? For partial answer let us turn for a moment to the past. When the cultivation of the sugar beet was begun it was the exception to find any samples which showed a content of sugar as high as 12%, while the general average was much below that. A system of careful selection was begun which has been kept up, till now, it is no uncommon thing to find beets running as high as 20%,

with the general average in the neighborhood of 15 to 16%. In 1871 eleven tons of beets were required to produce a ton of sugar while now only six or seven. At the present time nearly eight million tons of beet sugar are produced annually; we can see, therefore, what an immense amount has come through scientific cultivation. Similar work has been going on at Bloomington, Ill., and possibly elsewhere, in the study of corn. It was found upon analysis a few years ago that some samples of corn showed fully twice as much proteids as other amples. The idea was conceived of planting only seed of high protein content with the hope of greatly raising the general average. Since then hundreds of samples have been analyzed every year with results which at this time are very gratifying. Similar work has been done at the experiment stations of Minnesota and the Dakotas upon wheat with equally marked success.

Possibly one of the greatest achievements along this line has been in the improvement of cotton. As all know, there are two general varieties, sea island and upland, the former with much longer and more silky fibres than the latter. For many manufacturing processes only the long fibre variety is suited hence we have been compelled every year to import from Egypt and elsewhere hundreds of thousands of dollars worth of this sea-island cotton. By a system of cross breeding of native sea-island and upland, and careful selection it has been hoped to secure a variety that will nearly equal the imported article. Naturally such work is slow and tedious but government bulletins indicate that much success has already been attained and that there is great promise for the future.

A year or so ago the scientific world was celebrating the fiftieth anniversary of the great discoveries of Perkin—perhaps in many ways the most remarkable of modern times—discoveries which place within the reach of all the richest and most beautiful of colors which hitherto had been enjoyed by the wealthy alone; discoveries which in the case of a single dye are now saving annually to the world between twenty and thirty million dollars.

One of the most interesting chapters in all scientific history is the utilization of waste products. True, this has often come through legislation requiring the suppression of certain waste products which were a menace to public health or comfort. There are many such even to-day which in the future will un-

doubtedly be utilized. The unconsumed smoke of all our cities, the smelter gases, mostly sulphurous anhydride, which roll away in great billowy, yellow clouds from the smelting centers, like Pueblo, the street sweepings from our great cities, the black sands from our gold dredging, often very rich both in platinum and gold, the sewage from all towns and cities, now often a dreadful menace to the public health, as well as many others.

In this connection and with the great work of Perkin should be mentioned a series of experiments carried out in Germany by Professor Harries a year or so ago. We are all more or less familiar with the glucose industry in America. Were it not for the fact that glucose is such a well-known article of commerce, and so cheaply made, the conversion of sawdust, linen collars or cornstarch into the commercial article often known as "corn syrup" would seem a very wonderful achievement. But Professor Harries proposes to convert starch into rubber. What he really did was to oxidize by means of ozone pure native rubber into a substance he named diozonide. Later he converted this into an aldehyde and then by further oxidation into the corresponding acid. This acid which he made from caoutchouc, known as levulinic acid, can be readily prepared from starch. Having found that rubber may be converted into levulinic acid, may we not hope to be able to retrace our steps and prepare caoutchouc from levulinic acid? It does not seem improbable nor more wonderful than the work of Perkin in preparing from so unpromising a source as coal tar the beautiful diazo compounds so prized by all.

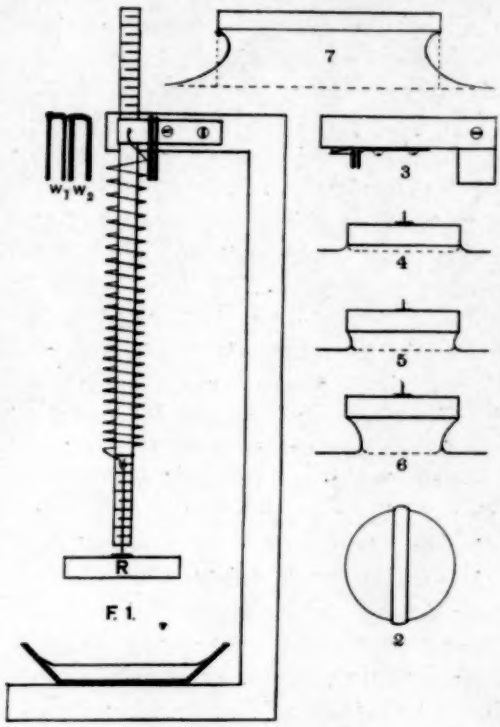
Such are but a few of the problems the chemist has solved or is now engaged in solving. In addition to the work, chemico-biological, of plant breeding already mentioned, the biologist has more serious problems at hand. Perhaps his greatest work will be in discovering the means of combating the natural enemies of the agriculturist. Countless millions of dollars in agricultural and horticultural crops now annually destroyed by insect and other pests must be saved and the problem is one of the greatest difficulty. It is claimed that the almost unequal fight now being waged by the horticulturist against his insect enemies is due largely to the wanton destruction of his bird friends; and even worse conditions will come unless decided steps are taken to save the birds. This can come only through an educative process and one vigorously carried out.

(To be continued.)

MEASUREMENT OF SURFACE TENSION.

EDWIN H. HALL.
Cambridge, Mass.

The drawings given below illustrate an exercise in the study of surface tension which I have found entirely practicable with a college class of beginners in physics and believe to be well suited to the capacity of pupils in secondary schools.



F. 1.

In Fig. 1, R is a ring of strip copper, about 0.017 cm. thick, which is shown also, as seen from above, in Fig. 2. The diameter of this ring is about 6.4 cm. and the figures, except No. 7, are all drawn nearly to scale. From a metal cross bar on this ring a copper wire, about 0.1 cm. thick and some 5 cm. long, extends upward and makes a hook connection with a spiral of hard-drawn German silver wire, about 0.05 cm. thick.* This spiral, the turns of which are about 2.5 cm. in diameter while in use, is soldered at its upper end to a strip of spring brass fastened to a wooden support. Behind this strip of brass, and held in place by it, is a narrow 30 cm. long scale of wood, graduated to mm. Fig. 3 gives a view from above of the top of the apparatus. W_1 and W_2 are pieces of copper wire, weighing 1 gm. and 2 gm. respectively, used in calibrating the spiral spring balance, which stretches about 1 cm. per gm. of load. When not in use W_1 and W_2 are suspended from the brass strip, as the figures show.

*No. 24 B. and S. gauge.

The wooden scale should be so placed within the spiral as not to touch any of the suspended parts. To facilitate this adjustment it is well to have the lowest half turn of the spiral annealed, in order that it may be readily bent to any required shape. The upper part of the wire is likely to be and should be annealed in the soldering operation.

Beneath R is a shallow vessel containing the liquid to be studied, alcohol, water or soap solution.

After the reduction factor of the spring balance has been found by the use of W_1 and W_2, the vessel containing the liquid, which we will suppose to be at first alcohol, is raised until the whole of the lower edge of R is submerged; then it is gradually lowered, while the experimenter notes the extension of the spring, fixing his attention for this purpose on the tip of the hook at the bottom of the spiral or on any other suitable point on the suspended parts below this. The liquid is by adhesion to the metal raised in a narrow ridge, thinning at the top to a film scarcely thicker than the copper itself, as in Fig. 4. Suddenly, after a pull of about 1 gram is indicated, the film gives way. Repetitions of the test, several of which can be made in a minute, show that the breaking force is a very well defined quantity, which, with the apparatus as here described, can be determined within, let us say, two or three per cent.

With clear water the experiment is conducted in the same way as with alcohol, though the maximum pull is now about three times as great as before. In either case an approximately correct value of the surface tension of the liquid under examination is found by dividing the maximum pull by twice the circumference of the ring, an attractively simple calculation. This ignores, of course, the fact that the external angle of contact of the film with the vertical surfaces of the ring is somewhat less than 180°. This inaccuracy tends to make the result somewhat too small. Whether the method as thus far described involves another small inaccuracy tending in the opposite direction will be considered later.

With soap solution, phenomena interesting in the qualitative aspect are to be observed. As the vessel is lowered, after contact of ring with solution, it will be noted that, as one would expect, a very much taller film can be obtained before rupture than with clear water, the maximum height which can be got and kept being, perhaps, as much as 2 cm. It will be found, too, and this may surprise some experimenters, that the max-

imum pull of the soap film is very much less than that of the clear water film. Moreover, this maximum pull is now found not just before rupture, but when conditions are not very different from those shown in Fig. 4. Increasing height of the film is accompanied by changes of shape, such as are indicated in Figs. 5 and 6, and by a marked diminution of total pull on the spring, till finally, and rather deliberately, the film parts from the liquid in the vessel, after which it becomes a horizontal diaphragm at the bottom of the ring.

The cause of the reduced total pull with increase of height of the film is of course to be found in the reduced circumference of the film at its vertical zone, where, and where only, the tension is vertical.

If to the pupil general instructions only are given, as to noting the behavior, changing pull and changing shape, of the soap film with changing height, without the help of such figures as are here shown, and if he is required to make drawings showing what he sees, a useful exercise in qualitative observation is provided for him, a kind of exercise which is rather difficult to arrange in great variety for young pupils in physics.

When I showed this apparatus at a meeting of the Eastern Physics Teachers' Association in October, 1908, a member asked whether the theory of the experiment would be equally simple if a disk were to be used instead of the ring. Certainly not. In fact, the disk form of apparatus would be quite unsuitable for school use. Fig. 7, in which the vertical scale is much larger than the horizontal, indicates the condition of things when a disk is used. The upper edge of the surface film of the liquid is now attached to the under face, not to the vertical side, of the disk and the curvature of the film is such as to relieve the liquid behind it from a part of the atmospheric pressure, so that the liquid beneath the whole expanse of the disk is raised above the general surface level. In fact, the curved surface film plays the part, to a certain extent, of the cylinder wall of a water pump, the disk, suspended by the spiral spring, acting as the piston. The load thus put on the spring is equal to the weight of a disk of the liquid which could be included between the bottom of the metal disk, the horizontal dotted line, and the vertical dotted lines of Fig. 7, and is very nearly, though not exactly, equal to the weight of the liquid actually raised above the general surface level, as indicated in that figure. In addition to this load there is, if we take account of the fact that the surface film is not exactly horizontal at the line of its attach-

ment to the disk, a further load due directly to the pull of the film on the disk, and equal to the vertical component of the total pull of the film on the disk. This latter part of the load is relatively small, if the disk has a diameter as great as that of the ring which we have been using, but the former part, due to the diminished upward pressure of the water against the under surface of the disk, as compared with the full atmospheric pressure downward on the upper surface, is perhaps four times as great as the load found with the ring.

It is now in order to ask whether in the case of the ring there is any element of hydrostatic pressure, as distinguished from the mere downward pull of the film, to be considered. There is such an element, though its importance is not very great. Against the whole horizontal lower edge of the ring, on an area equal therefore to the circumference of the ring multiplied by the thickness of the metal, the upward pressure of the liquid is less than the downward pressure of the atmosphere on the equal upper edge. This difference of pressure, which is a part of the load borne by the spring, is equal to the weight of a ring of the liquid of such size and shape as to make the geometrical extension of the metal ring from its lower edge to the general surface level of the liquid. The weight of this ring in the case of water is very likely as much as 0.1 gm., three per cent, let us say, of the total load shown by the spring, and in neglecting to subtract this quantity from the observed pull we make a correspondingly large error in the value found for the surface tension. On the other hand, neglect of the fact, mentioned above, that the angle of contact between the film and the copper is less than 180°, perhaps not more than 173°, we make an error of about one per cent in the opposite direction. Neither of these errors should be considered large in a brief exercise on surface tension.

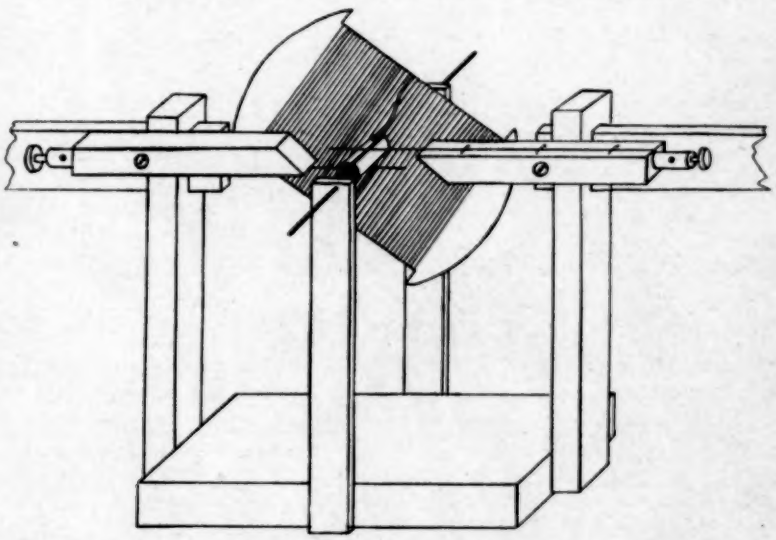
Taking, without selection or correction (save in the matter of misplaced decimal points), the values reported for the surface tension of distilled water by twenty members of a class, I find the mean to be 0.067 gm. per cm., which is several per cent smaller than the true value. It is quite possible that in some cases a trace of soap left on the ring from its previous use may have given too small a value. One report, included in the twenty mentioned above, put the surface tension as low as 0.03+. If this value had been rejected, the mean would have been 0.069, still too small, but not smaller, perhaps, than one is likely to get, unless very great pains are taken, with the comparatively elaborate and difficult capillary tube method.

APPARATUS TO ILLUSTRATE EARTH-INDUCTION, AND THE PRINCIPLE OF THE SIMPLE DYNAMO AND MOTOR.

By Henry S. Curtis,
Boys' High School, Brooklyn, N. Y.

Description.

The apparatus consists of an armature shaped as shown in figure, about three inches long and one and one-half inches wide. It is fixed to a four inch length of steel knitting needle, which serves as an axle. This axle rests in two holes bored in metal uprights, so that the axle is about four inches above the base of the apparatus. The armature is made of soft sheet iron, and is wound with about six layers of No. 22 insulated copper wire, and the terminals of the wire are soldered to the two sections of a



one inch long brass tube, slit on both sides, and insulated, so as to serve as a commutator. The brass tube is mounted on a cylinder of cork, through which the axle passes, the diameter of the tube being one fourth inch. It is bound to the cork cylinder with waxed thread. The armature and uprights are mounted on a wooden base, about six inches square, and at the two sides, so that the armature may revolve between, with a leeway of about an inch, are two wooden uprights, with slots cut facing the armature, so that magnets may be inserted, and act as field magnets to the revolving armature. On these uprights are set

small wooden cross pieces pointing in towards the commutator, and carrying straight pieces of copper wire. These wooden cross pieces are pivoted each on a single screw, so that the copper wire may be brought in contact with the commutator, and act as brushes. The outer ends of these wires lead to binding posts screwed into the outer ends of the cross pieces. The apparatus is very simple, and the cost of the material is slight.

In the original apparatus the core of the armature was made of a single thickness of soft sheet iron, cut out with shears, but I believe several layers would give a better effect. The diagram will make clear the general arrangement of parts.

Use of the Apparatus.

The apparatus may be made to show the following phenomena very nicely:

First. Earth-induction. If the apparatus be connected to a galvanometer (an ordinary laboratory astatic galvanometer is sufficiently sensitive, the current induced when the armature is spun around by hand in the earth's field may be plainly shown. A difference of deflection, also, may be noted, if the apparatus is shifted, so that the plane of the rotating armature is at different angles to the earth's lines of force.

Second. The principle of the dynamo may be shown by inserting the two bar magnets in the slots, with opposite poles facing the armature. The galvanometer will show currents opposite in direction, when the armature is rotating first in one direction and then in the other, or when the polarity of the field is reversed. Indeed, by holding one magnet in the hand, at a distance of several inches from the apparatus a marked deflection of the galvanometer may be obtained.

Third. The apparatus illustrates very well the principle of the motor by connecting several dry cells, in place of the galvanometer. The motor may be reversed by reversing the polarity of the field or the direction of the current.

NEW LINEAR EXPANSION APPARATUS.

DESIGNED BY GEORGE A. COWEN,

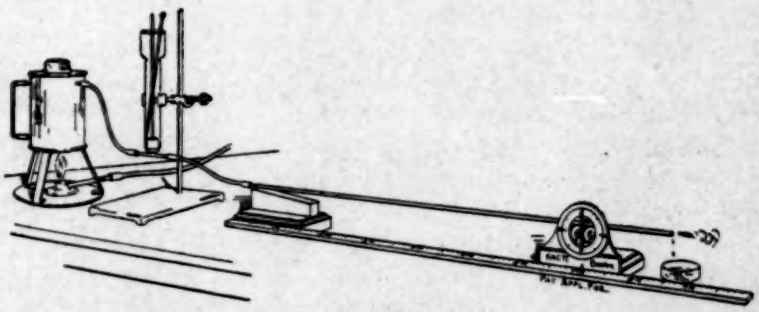
West Roxbury High School, Boston, Mass.

The design of this apparatus is such that it is possible for the student to take a large number of determinations during a single laboratory period.

It is found that where the student works with varying lengths of the same material, and also with different materials, that his knowledge concerning Linear Expansion is much more definite and real. In the apparatus here referred to, glass as well as metal tubes may be used, obtaining results of a degree of accuracy not usually obtained with the ordinary type of apparatus.

The greater number of determinations in a given period obtained with this apparatus is made possible by the ease with which water may be passed through the tube immediately after the steam is shut off. The complete record with the given length and material need not consume more than five minutes.

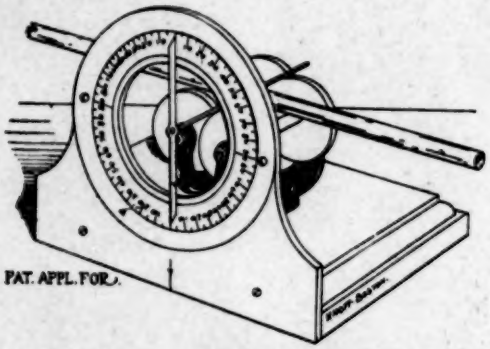
Referring to the cut, the tube is held at one end by a thin strip of metal which engages in a file- or saw-cut in the tube. When a glass in place of the metal tube is used, the method of securing this end is varied by putting on the tube a short section of rubber tubing in the surface of which a V-shaped cut is made.



The free end of the tube rests upon the axis of the indicator. This axis rests upon roller bearings so adjusted that the rolling friction of the wheels is less than the sliding friction of the tube on the axle, so that as the tube expands the axle revolves, carrying with it a light, evenly poised indicator, the amount of the expansion being determined by the relative rotation of the axle.

Different lengths of tube may be obtained by moving the indicating apparatus nearer to or further away from the fixed end of the tube. The Linear Expansion of the tube which is being used is easily determined by the meter stick placed as shown in the cut, there being a mark on the face of the base directly under the point of support.

Water Tank. To simplify the water tank problem the writer has found it convenient to use the student lamp chimney supported as indicated in the drawing. The temperature of the water is determined by reading the thermometer just before the water is allowed to pass through the tube. After the water has passed through the index is set at zero. The hole in the rubber stopper is then closed by means of the solid glass rod. Steam from the boiler is allowed to flow through the tube until the expansion as indicated by the rotation of the index has reached its maximum.



Computation. If the diameter of the axis be 0.2 cm. its circumference must be 0.62832 cm. If the index is moved through an arc of 60 degrees the expansion of the tube must have been 0.10472 cm.

For making a second determination the cold water which has previously been placed in the tank is allowed again to pass through the tube.

The wheels or roller bearings in the apparatus used to obtain the results given below were taken from the inclined plane car, while the dial was removed from the astatic galvanometer.

Expense. It is believed that this piece of apparatus will be much cheaper than the ordinary type, more easily handled and more readily comprehended by the pupil, while the results which the author has definitely determined will show errors with not

more than 20 per cent the error obtained by the older forms of instruments.

The tables below will show upon what the claim for accuracy is based. The laboratory directions given to the author's pupils will indicate how brief are the directions required.

In a class of about sixty pupils one half used the lever type and the other half the new style. All the results are here tabulated, and there has been no attempt to select the best. The results obtained with the lever type lie between .000015 and .0000216. With the new apparatus the results lie between .0000171 and .0000181. It will thus be seen by examination of the tables that the third significant figure has some value.

Instructor's Record.

	TEMP. WATER DEG.	STEAM DEG.	ANGLE DEG.	LENGTH	COEFFICIENT
Brass	8	100	65	70 cm.	0000177
	14	100.2	62	70 cm.	0000178
	20	100	57	70 cm.	0000178
Aluminum	21	100.3	72	80 cm.	0000228
	21	100.3	72	80 cm.	0000228
	21	100.3	72	80 cm.	0000228
	21	100.3	72	80 cm.	0000228
Glass	6	100	38	70 cm.	0000100
	8	100	37.5	70 cm.	0000101
	19	100.3	42	90 cm.	0000100
	20	100	32	70 cm.	0000099

Reasons for the Accuracy of the New Apparatus.

OLD.

An error of 0.5 mm, in rise of pointer changes coefficient .0000007.

An error of 0.5 mm. in length of short arm changes coefficient .0000003.

NEW.

An error of ½ degree on dial changes coefficient .0000001.

An error of 0.01 mm. in diam. of axle changes coefficient .0000001.

The chief source of error seems to be in reading the thermometer.

PUPIL'S RECORD. OLD STYLE.	PUPIL'S RECORD. NEW STYLE.	INSTRUCTOR'S RECORD. NEW STYLE.
0000 150	0000 171	0000 175
" "	" "	" 176
" "	0000 172	" "
0000 156	0000 173	0000 177
" "	0000 174	" "
0000 158	0000 175	" "
0000 159	" "	" "
0000 165	" "	" "
" "	" "	" "
0000 166	0000 176	" "
0000 167	" "	" "
0000 169	0000 177	" "
0000 173	" "	" "
0000 176	" "	" "
0000 177	" "	" "
0000 180	" "	" "
0000 181	" "	0000 178
0000 183	" "	" "
0000 184	0000 178	" "
0000 186	" "	" "
0000 187	" "	" "
0000 189	" "	" "
0000 194	" "	" "
0000 195	" "	
0000 196	0000 179	
0000 200	0000 180	
0000 216	" "	
	" "	
	0000 181	

DIRECTIONS GIVEN TO THE PUPIL.

Linear Expansion.

The purpose of this experiment is to find how much one centimeter of a tube expands in length if it is heated one degree.

Record the height of the barometer and from it calculate the temperature of steam. Calculate the circumference of the needle from the diameter given by the instructor, or measured by a micrometer.

Place the boiler and tank in such a position that either cold water or steam may be passed through the tube. Place the

cut at one end of the tube in such a position that it will be firmly held by the metal strip on the block. Place the other end on the axis of the recording apparatus and perpendicular to it. Have the first distance between the metal strip and the axis 70 cm. Allow water at about room temperature to pass through the tube. Just before the water stops flowing set the pointer at 0°. Allow steam to pass through the tube till the pointer comes to a rest. Record this new position.

Repeat using water about 10° colder than the room.

Make a third trial using 65 cm. of the tube and water of any temperature between 10° and 20°.

Arrange data as follows:

	1st.	2d.	3d.
Temperature of water.			
Temperature of steam.			
Rise of temperature.			
Circumference of axis.			
Rotation of axis.			
Part of a complete revolution has been made.			
Total elongation of the tube used.			
Length of the tube used.			
Elongation of one centimeter.			
Elongation of each cm. for one degree.			
Coefficient of linear expansion.			

[NOTE.—The L. E. Knott Apparatus Company are prepared to fill orders for the new form of apparatus.]

REGARDING A CERTAIN AXIOM.[1]

By E. R. Hedrick,

University of Missouri, Columbia.

Introduction.

This paper treats a question regarding elementary instruction which involves reasoning beyond the power of the ordinary high school student.

As teachers, we should and must consider phases of instruction far beyond the students whom we teach; if not, our very status as *teachers* might well be questioned. The conclusions alone of such discussions should affect actual class room work. The processes by which we arrive at these conclusions are *our* affair, if we are to accept the responsibility of deciding what should be taught and how.

Certainly I am not one to urge the introduction of novel and delicate considerations into the class room. If I discuss such a point, it must be understood that I emphatically urge you to avoid any long-drawn-out discussions of similar character before young students. Their minds are not prepared for what seem to us quite easy steps in a *philosophic* argument; their concepts of the subject they study will be confused rather than cleared by questions of philosophy or theories of pure logic, such as I shall present to you.

Trite as these statements are, they need to be emphasized: more than one teacher, enthusiastic for an adult theory which is easy to himself, has ruined his class work by injecting that theory, intended by its originator only for the teacher, into the center of his instruction. Even the nice considerations of Hilbert's Foundations of Geometry have been placed before young children!

The question of axioms is, and ever will be, young. Without making fundamental assumptions, no deductive science can hope for any conclusions whatever. The constant inspection of these fundamental assumptions is and always will remain a duty most pressing on all who feel responsible for the conduct of instruction.

The general question has been discussed repeatedly before this society. It is not my purpose to repeat those discussions,

[1] A paper read before the Missouri Society of Teachers of Mathematics and Science at its meeting in Columbia, Mo., on May 1, 1909.

but rather to present to you certain specific instances which seem interesting, and to discuss them in the light of elementary instruction.

The General Conclusions.

Let me first rehearse briefly the conclusions of certain recent papers, based on the original work of Peano, Hilbert, Poincaré, Russell, and others.

That an *axiom* is "a self-evident fact" is a common misstatement of which neither *Euclid* nor his most recent disciples are guilty. If the fundamental basis of our science is "self-evident," the logical conclusions will surely show no far-reaching results; for the *"axioms,"* if all are stated, contain essentially the whole of all possible logical conclusions.

An axiom, then, should be a dignified assumption, and should contain a kernel of truth not merely trivial, but be capable of vast powers of reproducing itself into weighty conclusions of usefulness to man.

The system of axioms, for logical purposes, should be free from contradictions, and should contain no hidden repetitions. But *for purposes of elementary teaching,* repetition is not fatal, and is even wise in certain cases. As for possible contradictions, the methods used to establish freedom from contradiction are too elaborate for conceivable use, even by those who would attempt to introduce this whole modern theory of axioms into actual class room work.

Finally, certain axioms logically necessary are not to be countenanced in elementary work; for example, the so-called *"axioms of order";* or, to be still more concrete, such an axiom as: "There are at least four points in space which do not all lie in one plane."

The direct effect of recent investigations lies more in the influence they exert upon our general mode of thought, than in any immediate contribution to our daily practice in elementary teaching.

A Special Instance.

One special instance will occupy the major portion of my time to-day. I refer to the statement, "Equals added to equals gives equals."

I have not called this an axiom. It will appear that it may or may not be so classed, but that its most usual use is not axiomatic in character, while in certain instances, it actually

contradicts other statements in some of our elementary texts.

It is usual to say, in elementary algebra, that two numbers are equal if they are the same number. Such a definition is reasonable and is to be found in practically all texts.

After this statement, we frequently see, as an *"axiom,"* the statement: "If equal numbers be added to equal numbers, the results will be equal." But this, reworded in accordance with the preceding definition, tells us merely that: "If a number be added to another number, and if this same addition is performed again, the two results are the same." It might seem that this statement conveyed absolutely no information. It does, however, tell us that *addition is a unique operation,* i. e., that two different results cannot be obtained by adding two numbers.

Only in this latter sense, namely, that addition is a unique operation, can the statement quoted be called an "axiom." Certainly this is NOT the meaning it conveys to most students, nor the meaning intended to be conveyed. That the addition of two numbers gives a unique result is never questioned in elementary work; this is another instance of an axiom which is *logically* necessary, but which is pedagogically neither necessary nor advisable.

Returning to the statement, "If equal numbers be added to equal numbers, the results are equal," we note that the real meaning, as explained above, is a purely technical necessity, not suited to children. The *intention* and the usual use of the statement, is to justify formally many operations upon equations. In this sense, it is NOT an axiom at all, but simply a corollary of the definition of equality, useful indeed as a standard reference, but not possessing the fundamental quality of an axiom, if we assume tacitly that the result of any addition is unique.

A similar conclusion holds regarding the like statements for multiplication, and so on. Indeed, if $f(x, y, z.....)$ is any single valued function of the numbers $x, y, z.....$ then $f(x, y, z.....)=f(x', y', z'.....)$ if $x=x', y=y'.....$

A FALLACY.

A conclusion often drawn from the statement quoted above is worthy of mention. It is frequently tacitly assumed, and all too often stated very formally, that any algebraic expression may be added to both sides of an equation without altering the values of the letters which satisfy that equation. A simple ex-

ample suffices to show that this is not true: the equation $x=0$ is satisfied when 0 is substituted for x; but if we add $1/x$ to each side, the resulting equation $x+1/x=1/x$ is not satisfied when 0 is substituted for x. This erroneous statement arises, of course, from a misuse of the original fact. For if we merely take care to see that the expression added to both sides really does represent a *number* for the values of x which satisfy the given equation, no false result can arise. Thus $1/x$, which we added to both sides just above, *does not represent a number when* $x=0$. Thus other cases are $x+\log x = \log x$ (no solution); $x + \sqrt{x} = \sqrt{x}$ (no solution in real numbers), etc.

The correct statement, in perfectly general form, is as follows: If $\phi(x)$ is defined and single valued for all values of x which satisfy the equation $f(x)=0$, then the equation $f(x)+\phi(x) = \phi(x)$ has the same roots as $f(x)=0$. It is to be noticed that the statement: "It is proper to cancel equal terms on opposite sides of an equation," is not absolutely true in general without qualification.

Use in Geometry.

The statement, "Equals added to equals give equals," has been variously used in geometry.

By some, it is stated and used only when applied to the numbers which measure geometric quantities. Used in this sense, it is precisely equivalent to the algebraic (or arithmetic) form discussed above; i. e., it is not axiomatic in character, if the usual agreements concerning equality and addition precede it in explicit or tacit form.

The statement is made, however, in texts in which the word "equals" is employed in other senses. For example, figures which are capable of superposition are called "equal" in many texts, though the use of the preferable word "congruent" is increasing.

If superposable figures are equal, and if the so-called axiom applies to all equal things, then addition of pairs of mutually superposable figures should give superposable figures. To test this, only a definition of addition is necessary. Two figures may be conceived as "added" in numerous ways. We may add the numbers which measure their areas or volumes; but such is not the intention when "equal" means superposable. We may conceive that addition means putting the figures into contact, and considering the total figure then formed. If so, the so-called axiom evidently fails, for the total figure in one case might NOT

be superposable on the total figure in the other case. Indeed the result of addition, under such a rule would not be unique, for juxtaposition can be accomplished in more than one way.

To my mind, this example, first of all, argues against the use of "equal" in the sense of superposable. Moreover, it emphasizes the point made above, that the so-called axiom amounts to a disguised statement that addition is unique.

The writer has called attention in a previous paper[2] to another misuse of the concept of equality in geometry, namely, to the traditional statement that "if two variables are equal their limits are equal."

Waiving the ambiguity so apparent in the last clause, the preceding statement is of course correct—*and* absolutely useless. If two variables are equal, they are identical, in so far as no specification is made of any special realm in which equality subsists.

CONCLUSION.

In conclusion, the whole result of my discussion is the analysis of one simple statement.

I have pointed out that it is axiomatic only in one sense, namely, in saying that addition is unique.

Waiving that point, which is and should be tacitly assumed in elementary work, the so-called axiom is merely a corollary of the usual definition of equality.

In using this corollary, care must be taken to avoid fallacy by assuring one's self that the thing added is really a number. One common fallacy, which enters directly in elementary work has been mentioned.

Finally, the use of this so-called axiom in geometry is properly algebraic (or arithmetic) in character; an attempt to extend its use to geometric concepts is replete with danger, and the use of "equal" in the sense of superposable is unfortunate.

These conclusions apply in the main to all the *similar* so-called axioms of the traditional list. Other axioms in algebra do exist and have a *just claim* to the name of axiom: among others the *distributive, commutative, and associative laws* of multiplication and addition. Whether these and other dignified axioms are stated as such or not, it seems fitting that the pseudo-axioms which I have discussed be assigned a place more fitting their trivial character; they are indeed, from the standpoint of elementary instruction, only corollaries, i. e., only self-evident facts—NOT by any means AXIOMS.

[2]Reference to "Approximations and Approximation Processes," SCHOOL SCIENCE AND MATHEMATICS, November and December, 1908.

ENGINEERING MATHEMATICS.

By Arthur E. Haynes,
University of Minnesota.

One may study mathematics with any one of three principal objects in view. First, for the mental discipline which the mastery of its principles and laws affords. Second, for the purpose of mastering such of these principles and laws and their practical application, as are involved in his chosen profession. Third, in order to make discoveries in the science, and thus to enlarge its boundaries. Each of these objects is legitimate, valuable, and commendable, and is worthy the highest effort of the individual. The first field is cultivated most largely, the second less so and the third least of all. This last field is that of discovery and of exploration. It is that in which the great names in the history of mathematics are found. If I were to rate these fields in the order of their importance to the mathematical world, I would reverse the foregoing order; but, if to the world of practical science, I would substitute the second for the first.

As I understand the term, Engineering Mathematics, it refers, not to the laws and principles of the science, but rather, to the practical application of these in the profession of engineering, to the method by which they are taught and to the special field of their application.

The term is equally justifiable with those of agricultural botany, agricultural chemistry, etc., and for reasons that are entirely similar. These reasons are briefly: (1) Because of the object sought in the study. (2) Because of the method of teaching required; and (3) Because of the special field covered by the study. First, then, the object involved in such a course of study is twofold—to master the principles involved and their intelligent practical application. Second, such a twofold object requires a method of teaching which constantly demands that the student shall test his understanding of the principles and rules by applying them to specific practical problems. Third, we thus naturally consider a field which is necessarily somewhat differentiated from that of pure mathematics; but which is highly important and to which the scientific world is largely indebted for its magnificent progress.

While engineering mathematics may not be taught in any large degree in the secondary schools, yet the methods employed in the teaching of mathematics in these schools could be greatly improved by adopting the method used in teaching the engineering mathematics, viz.: the method which requires the student

to illustrate and fix his knowledge by carefully and intelligently applying it. For example, if he has proved the rule for finding the volume of a sphere, then let him apply this to several spheres of different dimensions, and so on through the various problems of the high school geometry. Again, if he has made the formula for changing the reading of one thermometer to that of another, let him then solve a number of specific problems of this character. And so, in many places in the arithmetic, geography, geometry, algebra and physics of the secondary school, there will be ample opportunity to solve problems of a practical character and thus to acquire the splendid habit of learning how to employ the principles and rules of mathematics, intelligently, as tools, in securing practical results. Such teaching, too, will add tenfold interest to his work, and will prove doubly profitable whether he later studies engineering or not.

This method will also greatly aid in correlating the several branches where mathematics largely and naturally forms a common bond. As one example among many, I see no reason why the principles and use of the ordinary slide rule may not be mastered by the student of the secondary school, when properly taught, after studying the subject of logarithms, as presented in the text-book. In fact, it seems to me that here is the place to begin to teach the philosophy and use of this interesting, labor-saving device, and at the same time to fix and make more interesting and forceful the student's grasp of the subject. As a valuable aid in various mathematical investigations, I would advise the early use of coördinate paper, by the student.

If I read the signs aright, the mathematical world is coming more and more to believe in that sort of teaching, largely for the undergraduate, in which the student fixes his knowledge, by being required to apply it. I am confident that if the subject of mathematics in the grades and in the high schools were taught by the method used in most of our engineering colleges, it would result in a greatly increased interest in and a far better understanding of the subject on the part of the student, and that it would be much more satisfactory to all concerned.

Since writing the foregoing paper I have read with much profit and pleasure Professor John Dewey's "Moral Principles in Education," from which I quote the following as bearing in an interesting way upon it:

"The moment mathematical study is severed from the place which it occupies with reference to use in social life, it becomes unduly abstract, even upon the purely intellectual side. It is presented as a matter of technical relations and formulæ apart from any end or use. What the study of number suffers from in elementary education is lack of motivation. Back of this and that and the other particular bad method is the radical mistake of treating number as if it were an end in itself, instead of a means of accomplishing some end. Let the child get a consciousness of what is the use of number, of what it really is for, and half the battle is won."

INTERNATIONAL COMMISSION ON THE TEACHING OF MATHEMATICS.

Second Preliminary Report of the American Commissioners.

1. Sessions.

Since the publication of the first Preliminary Report, the Commissioners have held sessions in New York City on May 21 and 22, and on September 15, 1909.

2. Progress of the Work in America.

As a rule, the American Committees and Subcommittees are organized, and the list of acceptances is given below. Many of the subcommittees are already actively at work, and it is hoped that each subcommittee will now prosecute its work vigorously, in order that all subcommittee reports may be submitted by February 1st, 1910.

3. Progress of the Work in Europe.

At the September session Chairman Smith, returning from a summer in Europe, reported that the work of the Commission is progressing satisfactorily in all of the leading European countries. Several governments have taken official notice of the work, and there has been a gratifying spirit of coöperation shown by a large number of leading mathematicians and teachers.

4. Method of Work in America.

The general plan of the American investigation was outlined in the first Preliminary Report, but numerous inquiries make it seem desirable to supplement that outline with the following specific suggestions relative to the work of the separate subcommittees.

a. *Scope of work.* The field of work of each subcommittee is to be interpreted broadly. In case of doubt as to whether or not the field of the subcommittee, as indicated by the title, covers a certain topic or phase of work, it would be in place for the subcommittee to treat that topic or phase of work. It is desired that each subcommittee give its topic the most adequate presentation possible, and to this end it should allow itself all needed latitude both as to scope of work and style of treatment.

b. *Duplications.* It is obvious that in consequence of the preceding interpretation of the scope of the work as well as in consequence of the list of topics for the various committees and subcommittees themselves, the same topic will often be treated by several committees. This is desirable in so far as it secures

careful discussions from various points of view, and indeed seems the only way in which, under our geographic and other conditions, the expression of the best thought of the whole country can be secured. It would be desirable, therefore, for each subcommittee to treat its topic fully and adequately without reference to the likelihood (or even certainty) that other subcommittees will also treat some or all of the topics in hand. Conference between subcommittees and coöperation when possible and advantageous, are, of course, always in order. It will be one of the duties of the various committees (which it will be recalled are made up of the chairmen of the subcommittees) to consider the question of how to deal best with such matter as may occur in duplicate in the reports of the subcommittees.

c. *Length of Reports.* It would seem conducive to the most efficient work if the various subcommittees were to give adequate expression to their best thought, at whatever length may be requisite. If the totality of the reports thus prepared should be of too great extent for complete publication, the question of condensation with the least loss of valuable content, will of course be taken up.

d. *Discussion of proposed reports.* It is hoped that the proposed reports may be presented and discussed in as many meetings of teachers and mathematicians as possible, to the end that they may, when finally submitted, reflect the sentiment of the teaching profession and of the mathematicians of the country.

5. THE ORGANIZATION OF THE COMMITTEES AND SUBCOMMITTEES.

The list of committees and subcommittees presented in the First Preliminary Report has been somewhat changed to conform to wishes of chairmen and to meet various exigencies.

It was originally proposed, whenever feasible, to select as members of any single subcommittee persons residing sufficiently near to each other to make practicable frequent meetings for personal conference. Although thus no single report would be representative of the country as a whole, it was hoped that the totality of the reports would be so. For various reasons (among others, the desires of chairmen for wider representation on their committees) this plan has been carried out to a very slight extent only, but its influence may be clearly seen in the plan of the committees and subcommittees and may also be traced in the membership of certain subcommittees.

6. The Advisory Council.

The membership of the Advisory Council is as follows:

The Honorable Elmer Ellsworth Brown,
United States Commissioner of Education, Washington, D. C.

A. Lawrence Lowell,
President of Harvard University, Cambridge, Mass.

Nicholas Murray Butler,
President of Columbia University, New York City.

Harry Pratt Judson,
President of the University of Chicago, Chicago, Ill.

J. Howard Van Amringe,
Ex-President of the American Mathematical Society, Columbia University, New York.

Emory McClintock,
Ex-President of the American Mathematical Society, 32 Nassau Street, New York.

George W. Hill,
Ex-President of the American Mathematical Society, West Nyack, N. Y.

Robert S. Woodward,
Ex-President of the American Mathematical Society, The Carnegie Institution, Washington, D. C.

Eliakim H. Moore,
Ex-President of the American Mathematical Society, The University of Chicago, Chicago, Ill.

Thomas S. Fiske,
Ex-President of the American Mathematical Society, Columbia University, New York City.

William F. Osgood,
Ex-President of the American Mathematical Society, Harvard University, Cambridge, Mass.

Henry S. White,
Ex-President of the American Mathematical Society, Vassar College, Poughkeepsie, N. Y.

Maxime Bôcher,
President of the American Mathematical Society, Harvard University, Cambridge, Mass.

H. W. Tyler,
President of the American Federation of Teachers of the Mathematical and Natural Sciences, Massachusetts Institute of Technology, Boston, Mass.

7. The Membership of the Committees and Subcommittees.

I. General Elementary Schools.

Chairman, Superintendent C. N. Kendall, Indianapolis, Ind.

1. *Kindergarten.*
   Chairman, Miss Patty Hill, Teachers College, Columbia University, New York.
   Miss Alice Temple, Kindergarten Department, School of Education, The University of Chicago, Chicago, Ill.
   Miss Elizabeth Harrison, Kindergarten College, 1200 Michigan Avenue, Chicago, Ill.
2. *Public and Private Schools—Grades 1-6, topics a-d.*
   Chairman, Miss Theda Gildemeister, Normal School, Winona, Minn.
   Miss Harriet Peat, Normal School, Salem, Mass.
   Miss Julia Martin, Manchester, Mich.
   Professor Henry Suzzallo, Columbia University, New York City.
   Dr. C. W. Stone, Normal School, Farmville, Va.
3. *Same schools, Topic e.*
   Chairman, F. G. Bonser, State Normal School, McComb, Ill.
   Miss Lao G. Simons, Normal College, New York City.
   Professor William J. MacAuliffe, Cathedral College, 462 Madison Avenue, New York City.
4. *Public and Private Schools, Grades 7 and 8, topics a-d.*
   Chairman, W. W. Hart, Shortridge High School, Indianapolis, Ind.
   Professor William L. Benitz, Notre Dame, Ind.
5. *Same Schools, Topic e.*
   Chairman, Professor Ira S. Condit, Iowa State Teachers' College, Cedar Falls, Ia.
   J. O. Mahoney, Dallas, Tex.
   Professor W. C. Bagley, University of Illinois, Urbana, Ill.
   George Melcher, Normal School, Springfield, Mo.
   Dr. C. O. Dewey, 467 MacDonough Street, Brooklyn, N. Y.

II. Special Kinds of Elementary Schools.

Chairman, Professor George B. Strayer, Teachers College, Columbia University, New York.

1. *Trade Schools, Topics a-d.*
   Chairman, E. B. Kent, 9 Brunswick St., Jersey City, N. J.
   Miss Mary E. Edwards, California School of Industrial Art, Sixteenth and Utah Streets, San Francisco, Cal.
   George B. Miller, Cogswell Polytechnic College, San Francisco, Cal.
2. *Corporation Industrial Schools, Topics a-d.*
   Chairman, Henry Gardner, Assistant Superintendent of Apprentices, N. Y. C. R. R., New York City.
   Major A. W. Lowe, American Society of Naval Engineers, 1 Olive Street, Lynn, Mass.
   William D. Earnest, John Wanamaker Commercial Institute, Tenth Street and Broadway, New York.
   W. B. Russell, Director Franklin Union, Appleton and Berkeley Streets, Boston, Mass.

3. *Industrial Classes in Public Schools, Topics a-d.*
   Chairman, H. S. Youker, Normal School, Oshkosh, Wis.
   Jane Mathews, 1013 Chestnut Avenue, Altoona, Pa.
   T. O. Hubbard, Principal High School, Fond du Lac, Wis.
4. *Teachers for All the Above Schools.*
   Chairman, Principal W. A. Baldwin, Normal School, Hyannis, Mass.
   Miss Sarah J. Walter, Hampton Institute, Hampton, Va.
   Principal Charles F. Warner, Technical High School, Springfield, Mass.
   Superintendent Johnson, School for Feeble Minded, Vineland, N. J.
   John T. Prince, Agent Massachusetts Board of Education, Newton, Mass.

III. Public General Secondary Schools.

Chairman, George W. Evans, Charlestown High School, Boston, Mass.

1. *Boys' Schools, Topics a-d.*
   Chairman, Henry M. Wright, English High School, Boston, Mass.
   John W. Regan, High School, Charlestown, Mass.
   Samuel B. Tinsley, Male High School, Louisville, Ky.
   Harry English, Central High School, Washington, D. C.
2. *Girls' High Schools, Topics a-d.*
   Chairman, Ernest G. Hapgood, Girls' Latin School, Boston, Mass.
   Miss A. Laura Batt, English High School, Summerville, Mass.
   Emma H. Carroll, Girls' High School, 1629 South Sixteenth Street, Philadelphia, Pa.
   Grace C. Alden, 84 Franklin Street, Lynn, Mass.
   T. H. Garrett, Tubman High School, Augusta, Ga.
3. *Co-Educational Schools in the East, Topics a-d.*
   Chairman, Charles D. Meserve, Newton High School, Newton, Mass.
   Daniel D. Feldman, Erasmus Hall High School, 288 Rugby Road, Brooklyn, N. Y.
   A. R. Taylor, High School, Montclair, N. J.
4. *The Same in the Middle West.*
   Chairman, Charles Ammerman, 3640 Juniata Street, McKinley High School, St. Louis, Mo.
   Miss Mabel Sykes, South Chicago High School, South Chicago, Ill. (438 E. 57th Street.)
   Miss Lucie W. Allen, Laurium, Michigan.
   Miss Edith Long, High School, Lincoln, Neb.
   W. Lee Jordan, 2830 Battlebow Avenue, Des Moines, Iowa.
5. *The Same in the South.*
   Chairman, Professor Floyd Field, Georgia School of Technology, Atlanta, Ga.
   P. H. Underwood, Ball High School, Galveston, Tex.
   Mrs. Annie E. Cooney, High School, 200 Market Avenue, Memphis, Tenn.
   Alfred Livingston, Principal High School, Henderson, Ky.
6. *The Same on the Pacific Coast.*
   Chairman, H. P. Gaylord, Throop Polytechnic Institute, Pasadena, Cal.
   Professor C. A. Noble, 2731 Durant Avenue, Berkeley, Cal.

J. C. Keith, 1629 35th Avenue, Broadway High School, Seattle, Wash.

E. H. Barker, Polytechnic High School, 1940 Park Grove Avenue, Los Angeles, Cal.

Professor E. E. DeCou, 719 Mill Street, Eugene, Ore.

Miss T. A. Brookman, High School, Berkeley, Cal. (2246 Atherton Street.)

Professor R. E. Moritz, Seattle, Wash.

7. *Teachers for All the Above, Topic e.*

Chairman, Professor L. D. Ames, The University of Missouri, Columbia, Mo.

Dr. L. C. Karpinski, The University of Michigan, Ann Arbor, Mich.

F. C. Touton, The High School, Kansas City, Mo.

Oscar W. Anthony, DeWitt Clinton High School, New York City.

8. *The Six Year Curriculum.*

Chairman, Professor Arthur Sullivan Gale, The University of Rochester, Rochester, N. Y.

Dr. C. T. McFarlane, Principal of the State Normal School, Brockport, N. Y.

Miss Katherine Bell, High School, Lead, S. D.

Gilbert B. Morrison, Principal McKinley High School, St. Louis, Mo.

William H. Norton, Boys' Latin School, Boston, Mass.

9. *Failures in the Technique of Secondary Teaching of Mathematics: Their Causes and Remedies.*

Chairman, William Betz, East High School, Rochester, N. Y.

Miss M. E. Shea, High School for Girls, 4404 Samson Street, Philadelphia, Pa.

Miss Mary M. Wardwell, Central High School, Buffalo, N. Y.

H. E. Webb, High School, Newark, N. J.

IV. Private General Secondary Schools.

Chairman, Principal W. E. Stark, Ethical Culture School, Central Park West, New York.

1. *Boys' Schools, Including Religious and Military, Topics a-e.*

Chairman, Dr. John S. French, Principal Morris Heights School, Providence, R. I.

Walter R. Marsh, Principal St. Paul's School, Garden City, N. Y.

Dr. J. L. Patterson, Principal Chestnut Hill Academy, Chestnut Hill, Phila.

Professor William Schwartz, Cathedral College, 462 Madison Avenue, New York.

William Hughes, Principal Branham and Hughes School, Spring Hill, Tenn.

Josiah Bartlett, Riverview Academy, Poughkeepsie, N. Y.

Franklin T. Jones, University School, Cleveland, Ohio.

2. *Girls' Schools, Including Religious, Topics a-e.*

Chairman, S. A. Courtis, Detroit Home and Day School, Detroit, Mich.

Miss Emma M. Cowles, Milwaukee Downer College, Milwaukee, Wis.

Miss Sarah M. Lake, Miss Winsor's School, 95 Beacon Street, Boston, Mass.
Dr. Ruth G. Wood, Smith College, Northampton, Mass.
Harriet D. Buckingham, Girls' High School, Lexington, Mass.
Dr. Virginia Ragsdale, Baldwin School, Bryn Mawr, Pa.
Miss Vevia Blair, Sachs School for Girls, New York City.

3. *Co-Educational Schools, Topics a-e.*
Chairman, C. W. Newhall, Shattuck School, Faribault, Minn.
G. H. Albright, Colorado College, Colorado Springs, Colo.
E. R. Breslich, University High School, University of Chicago.
George P. Tibbetts, Williston Seminary, East Hampton, Mass.
E. J. Owen, Pillsbury Academy, Owatonna, Minnesota.
Laura A. Whyte, Norwich Free Academy, Norwich, Conn.

V. Normal Schools.

Chairman, E. H. Taylor, State Normal School, Charlestown, Ill.

1. *State Normal Schools, Topics a-d.*
Chairman, H. Clay Harvey, State Normal School, Kirksville, Mo.
S. F. Parsons, State Normal School, DeKalb, Ill.
Dr. J. D. Faught, State Normal School, Marquette, Mich.
J. C. Stone, Montclair, N. J.
William A. Cornish, State Normal School, Cortland, N. Y.
George C. Shutts, State Normal School, Whitewater, Wis.
W. C. Vernon, Austin, Tex.

2. *Private Normal Schools.*
Chairman, M. E. Bogarte, Normal University, Valparaiso, Ind.
Fred L. Pauly, National Normal University, Lebanon, Ohio.
Thomas W. Keenan, Shenandoah, Iowa.
Albert J. Harpman, Austin, Minn.

3. *Teachers for Normal Schools.*
Chairman, J. C. Brown, State Normal School, Charleston, Ill.
Joseph V. Collins, Stevens Point, Wis.
George W. Hull, Millersburg, Pa.
J. H. Scarborough, Warrensburg, Mo.
Sands Wright, Cedar Falls, Iowa.

VI. Technical Secondary Schools.

Chairman, Professor C. N. Haskins, 46 S. Main Street, Dartmouth College, Hanover, N. H.

1. *Public, Private and Corporation Trade Schools.*
Chairman, F. D. Crawshaw, University of Illinois, Urbana, Ill.
Professor N. C. Riggs, Carnegie Technical Institute, Pittsburg, Pa.
Professor H. V. Gunmere, Drexel Institute, Philadelphia, Pa.
Professor C. A. Bennett, Bradley Polytechnic Institute, Peoria.
C. F. Berry, Principal Milwaukee Trade School.
E. C. Barker, Polytechnic High School, Los Angeles, Cal.

2. *Commercial Schools, Public and Private.*
Chairmanship and membership now being considered.

3. *Agricultural Schools.*
Chairmanship and membership now being considered.

VII. MISCELLANEOUS TYPES OF SECONDARY AND OF ELEMENTARY SCHOOLS NOT INCLUDED UNDER II.

Chairman, Superintendent William H. Elson, Cleveland, Ohio.

1. *Evening Technical Schools.*
   Chairman, A. D. Dean, Albany, N. Y., Chairman State Department of Education.
2. *Private Correspondence Schools.*
   Chairman, W. F. Rocheleau, Interstate School of Correspondence, Chicago, Ill.
3. *Schools for Licensed Accountants.*
   Chairman, W. D. Higdon, McKinley High School, St. Louis, Mo.
4. *Schools for Negroes and Indians.*
   Chairman, Mr. Hill, Tuskegee Institute, Ala.

VIII. EXAMINATIONS IN MATHEMATICS OTHER THAN THOSE SET BY THE TEACHER FOR HIS OWN CLASSES.

Chairman, Professor T. S. Fiske, Columbia University, N. Y.

1. *Nature of Promotion in Elementary Schools and Admission to Secondary Schools.*
   Chairman, H. C. Pearson, Horace Mann School, New York City.
   H. B. Loomis, Hyde Park High School, Chicago, Ill.
   John S. Rackliffe, Huntington School, Brockton, Mass.
2. *Entrance to College by College Examinations.*
   Chairman, Professor H. D. Thompson, Princeton, N. J.
   Professor J. L. Coolidge, Harvard University, Cambridge, Mass.
   Professor Julius Sachs, Columbia University, N. Y.
   Professor L. S. Hulburt, Johns Hopkins University, Baltimore, Md.
   Principal J. B. Schobinger, The Harvard School, Chicago.
3. *The Same by College Entrance Board Examinations.*
   Chairman, Professor V. Snyder, Cornell University, Ithaca, N. Y.
   Professor R. W. Prentiss, Rutger's College, New Brunswick, N. J.
   Professor C. L. E. Moore, Massachusetts Institute of Technology, Boston, Mass.
   Miss C. A. Hart, Wadleigh High School, 163 West 105th Street, New York.
4. *The Same by State Examinations.*
   Chairman, Dr. C. F. Wheelock, Bureau of Education, Albany, N. Y.
   President J. M. Taylor, Vassar College, Poughkeepsie, N. Y.
   Superintendent F. D. Boynton, Ithaca, N. Y.
5. *The Same by Certification.*
   Chairman, Professor N. F. Davis, Brown University, Providence, R. I.
   Professor E. S. Crawley, University of Pennsylvania, Philadelphia, Pa.
   Professor George C. Edwards, University of California, Berkeley, Cal.
   Professor W. W. Beman, Ann Arbor, Mich.
   Professor William M. Thornton, University of Virginia.
6. *State and Local Examination of Teachers.*
   Chairman, Hon. Robert J. Aley, Indianapolis, Ind.
   Superintendent, J. C. Byrnes, 500 Park Avenue, New York City.

Harry English, High School, Washington, D. C., 2907 P St., N. W.

7. *Civil Service and Other State Systems of Examinations.*
   Chairman, Charles S. Fowler, 165 Broadway, New York City.
   Gordon Colby, Chief Examiner Civil Service, Trenton, N. J.
   G. R. Wales, Chief Examiner, U. S. Civil Service Commission, Washington, D. C.
   Henry Sherwin, Chief Examiner, Civil Service Commission, Boston, Mass.
8. *Examination of Actuaries.*
   Chairman, J. H. Gore, President of the Actuarial Society of America, Actuary of the Prudential Life Insurance, Newark, N. J.
   Dr. H. J. Messenger, Actuary of the Travelers, Hartford, Conn.
   Dr. William M. Strong, Assistant Actuary of the Mutual Life Insurance of New York, 32 Nassau Street, New York City.
   Mr. Dow, Actuary of the N. E. Mutual Life Insurance Co.

IX. MATHEMATICAL WORK IN AMERICAN POSSESSIONS.

Chairman, Dr. Fred W. Atkinson, President of the Polytechnic Institute, Brooklyn, N. Y.

1. *In the Philippine Islands.*
   Chairman, Hon. David P. Barrows, Manila, P. I.
2. *In Hawaii.*
   Chairman, Hon. W. H. Babbitt, Honolulu, Hawaii.
3. *In Porto Rico.*
   Chairman, Hon. Edwin G. Dexter, Porto Rico.
4. *In Alaska.*
   Chairman, Hon. Wilford B. Hoggatt, Governor of Alaska.

X. INFLUENCES TENDING TO IMPROVE THE WORK OF THE TEACHER.

Chairman, Professor E. P. Cubberley, Leland Stanford, Jr., University, Palo Alto, Cal.

1. *Scientific Societies and Periodical Literature.*
   Chairman, Professor F. N. Cole, Columbia University, New York.
   Professor W. H. Metzler, Syracuse University, Syracuse, N. Y.
   Professor J. E. Gould, The University of Washington, Seattle, Wash.
   Professor B. F. Finkel, Drury College, Springfield, Mo.
   Dr. Thomas J. MacCormack, La Salle, Ill.
2. *Teachers' Associations, Including Reading Circles.*
   Chairman, Professor Gustave Legras, College of the City of New York, New York City.
   A. Harry Wheeler, 8 Shawmut Street, English High School, Worcester, Mass.
   William E. Breckenridge, Stuyvesant High School, New York City.
   D. M. Philip, College of the City of New York.
   W. A. Merrill, West High School, Des Moines, Ia.
   George Alvin Snook, Central High School, Philadelphia, Pa.
   John B. Cleveland, Normal School, Los Angeles, Cal.
3. *Teachers' Institutes.*
   Chairman, Dr. A. W. Stamper, Chico, Cal.
4. *State Inspection and Supervision of Instruction.*
   Chairman, Professor E. B. Skinner, The University of Wisconsin, 210 Lathrop Street, Madison, Wis.

Dr. E. W. Lyttle, Department of Education, Albany, N. Y.
Dr. John E. Clarke, Cambridge, Mass.

5. *Activities of Publishers and their Agents.*
Chairman, Dr. L. L. Jackson, care of D. Appleton & Co., 29 W. 32nd St., New York City.
D. W. Hall, care of Ginn & Co., 2301 Prairie Avenue, Chicago.
R. L. Short, Technical High School, Cleveland, Ohio.

6. *The Question of Securing Acceptable Candidates for the Teaching Profession. Information as to the Well-Being of Teachers and the Causes of Unattractiveness of the Work.*
Chairmanship and membership now being considered.

XI. TECHNOLOGICAL SCHOOLS OF COLLEGIATE GRADE.

Chairman, Professor H. W. Tyler, Massachusetts Institute of Technology.

1. *Independent Technological Schools.*
Chairman, Professor C. S. Howe, Case School of Science, Cleveland, Ohio.
Professor A. M. Kenyon, Purdue University, Lafayette, Ind.
Professor D. F. Campbell, Armour Institute, Chicago, Ill.

2. *Technological Departments of College and Universities.*
Chairman, Professor A. Ziwet, Ann Arbor, Mich.
Professor E. R. Hedrick, Columbia, Mo.
Professor E. V. Huntington, Cambridge, Mass.
Professor E. E. Slocum, The University of Cincinnati, Cincinnati, Ohio.

XII. OTHER PROFESSIONAL SCHOOLS OF COLLEGIATE GRADE SEPARATE OR CONNECTED WITH COLLEGES OR UNIVERSITIES.

Chairman, Professor G. W. Myers, School of Education, The University of Chicago, Chicago, Ill.

1. *For the Training of Teachers.*
Chairman, C. B. Upton, Teachers' College, Columbia University, New York.

2. *For the Training of Army Officers, Including Schools for Graduates of West Point.*
Chairman, Professor C. P. Echols, West Point, N. Y.
Major Tracy C. Dickson, Ordnance Department, Sandy Hook, N. J.
Captain Alston Hamilton, Artillery School, Fortress Monroe, Va.

3. *For the Training of Naval Officers, Including Schools for Graduates of Annapolis.*
Chairman, W. J. King, Annapolis, Md., 232 Prince George St.
Professor E. J. Yowell, Annapolis, Md.
Professor C. H. Sisam, Urbana, Ill.

XIII. COLLEGES OF LIBERAL ARTS AND UNIVERSITIES STATE AND ENDOWED.

Chairman, Professor H. S. White, Poughkeepsie, N. Y.

1. *Men's Colleges.*
Chairman, Professor F. C. Ferry, Williamstown, Mass.

2. *Women's Colleges.*
Chairman, Professor W. H. Maltbie, Woman's College, Baltimore, Md.

3. *Co-Educational Colleges.*
   Chairman, Professor Thomas F. Holgate, Northwestern University, Evanston, Ill.
   Professor Sellew, Knox College, Galesburg, Ill.
   Professor Keppel, The University of Florida, Gainesville, Fla.
   Professor T. A. McKinney, The University of South Dakota, Vermillion, S. D.
   Professor James W. Glover, University of Michigan, Ann Arbor, Mich.

XIV. GRADUATE WORK IN UNIVERSITIES AND IN OTHER INSTITUTIONS OF LIKE GRADE.

Chairman, Professor Maxime Bôcher, Harvard University.

1. *Courses of Instruction.*
   Chairman, Professor D. R. Curtiss, Northwestern University, Evanston, Ill.
   Professor Edward Kasner, Columbia University, New York.
   Dr. A. C. Lunn, The University of Chicago, Chicago, Ill.
2. *Preparation for Research and the Doctor's Degree.*
   Chairman, Professor Percy F. Smith, Yale University.
   Professor M. B. L. Mason, The University of Wisconsin, Madison, Wis.
   Professor E. J. Wilczynski, The University of Illinois, Urbana, Ill.
   Professor J. I. Hutchinson, Cornell University, Ithaca, N. Y.
   Professor G. D. Birkhoff, The University of Wisconsin, Madison, Wis.
3. *Preparation of Instructors for Colleges and Universities.*
   Chairman, Professor E. B. Van Vleck, The University of Wisconsin, Madison, Wis.
   Professor H. E. Slaught, The University of Chicago.
   Professor C. L. Bouton, Harvard University.
   Professor H. E. Hawkes, Yale University.
   Professor G. D. Olds, Amherst College, Amherst, Mass.

XV. GENERAL QUESTIONS.

Chairman, Professor H. E. Cobb, Lewis Institute, Chicago, Ill.

1. *Schematic Survey of American Educational Institutions, Their Sequence and Interrelations.*
   Professor David Snedden, Teachers' College, Columbia University, New York City.
   Professor J. H. Tanner, Cornell University, Ithaca, N. Y.
   Professor E. Holland, University of Indiana, Bloomington, Ind.
   Superintendent E. E. Spaulding, Newton, Mass.
   Professor Edward C. Elliott, Madison, Wis.
2. *The Scope and Arrangement of the Mathematical Curriculum in Elementary and Secondary Schools.*
   Chairman, Professor C. E. Comstock, Bradley Polytechnic Institute, Peoria, Ill.
   Dr. D. E. Felmley, Normal, Ill.
   A. M. Curtis, Normal School, Oneonta, N. Y.
   Principal E. L. Brown, North High School, Denver, Colo.
   Dr. J. T. Rorer, Central High School, Philadelphia, Pa.

REPORT OF COMMITTEE OF MATHEMATICS SECTION OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS ON REAL APPLIED PROBLEMS IN ALGEBRA AND GEOMETRY.

Scope of the Investigation.

This committee, created by the Central Association of Science and Mathematics Teachers at its meeting in November, 1908, was instructed to investigate the possibilities of collecting the real applied problems of elementary algebra and geometry in the various practical fields where they are to be found, and of using them in teaching these subjects in the secondary schools. The committee, since the completion of its membership in February, has been working earnestly at the investigation. But the work involved is of such magnitude that in the few intervening months only a superficial investigation could be made, and hence the report which is here submitted must be of a preliminary character.

Of the two phases of the investigation assigned to the committee, viz., (1) the determination of the extent of the direct applications of elementary algebra and geometry in practical life and the collection of a fund of real applied problems, and (2) the determination of their adaptability for teaching algebra and geometry to secondary school pupils, it is only the first phase that the committee has been able to consider. Of course, in the collection of the problem material the opinion of the members of the committee has been exercised as to the probable adaptability of it to the interests and capacities of pupils in the secondary schools.

Analysis of the Real Problem Movement.

An analysis of the real problem movement, and an interpretation of its significance for the teaching of secondary mathematics, should be made here.

The real problem movement aims to reform the teaching of secondary mathematics by teaching the different subjects more in relation to their uses in solving the problems that are actually encountered in life. Instead of teaching algebra and geometry as *pure sciences*, almost entirely abstract in nature, with practically all of the applied problems that are used artificial, and made up to illustrate the principles and processes involved without reference to their reality in actual life; it is proposed to gather up and use in the class rooms of the secondary schools, as far as possible, the genuine applied problems of algebra and geometry that are really encountered in the activities of boys and girls, in ordinary everyday life, in the sciences and arts, and in the various practical industrial vocations. Algebra and geometry are to be looked upon by the pupil, not merely as a means of mental discipline, a means of developing his mind, but as *tools* to be used in doing the world's work. The subjects are to be so taught as to give a true and adequate conception of their uses in the various practical fields of activity.

Looking at the matter from the standpoint of the culture, to secure a maximum of mental development there must be motive and interest in the study. This motive and interest in the work, on the part of the pupil, will be vastly increased by using, in place of general, abstract, and artificial problems, the genuine applied problems encountered in the world's work that are clothed with human interest and full of real life. And looking at the matter from the standpoint of utility, if the knowledge of algebra and geometry is to function in the practical life of the individual, if the pupil is going to have facility in applying the principles of these subjects in the solutions of real concrete situations in adult life, he must have that facility developed by practice in solving just such real concrete situations in school. One of the chief contributions of modern psychology to education is on this point. Hence it is believed to be the duty of the school to assist the knowledge of algebra and geometry to function by teaching the pupil to use this knowledge while still in school in the solution of the problems actually encountered in practical life.

When considered in its relation to general educational theory, the movement has to do with the great problem of *educational waste* in the teaching of secondary mathematics, the problem of the maladjustment of the curriculum to the needs and interests of the pupil.

Algebra and geometry were at one time college subjects, and in the growth of educational institutions have been handed down to the secondary schools from the colleges. In the colleges these subjects were taught from the standpoint of pure sciences, and when introduced into the secondary schools, where they were studied by less mature minds, they continued to be taught in the same way. Thus, geometry until to-day has continued to be taught with practically the content given to it by the Greeks, a content adapted to the speculative minds of Greek philosophers and mathematicians. Euclid did not write for boys and girls. Now we are coming to see that algebra and geometry as thus taught are not well adapted to the interests and needs of secondary school pupils.

The fundamental idea that has prevailed in the teaching of these subjects is the idea of education as a *discipline*. In this old theory of education *the present needs and interests of the individual* are not taken into account. These are sacrificed for the sake of the future. Education is made primarily a preparation for the future.

This disciplinary theory of education, as a theory, has now become obsolete. As opposed to the disciplinary idea, education is seen to be *growth* or *development*, the unfolding of the latent powers of the individual. The *present* is emphasized, as well as the future. Education is identified with living. The emphasis, therefore, is to be placed upon the present needs and interests of the pupil in teaching algebra and geometry, rather than upon mere mental discipline alone as a preparation for adult life. Indeed, it is by appealing to the *present* interests and by properly meeting the *present* needs of the pupil that the maximum of mental development and the best preparation for adult life are to be obtained. This growth of the recognition of the individual, with his present needs, interests, and activities, as the center in the teaching

process has brought about almost a complete transformation of arithmetic in the elementary schools within the last few decades. In the teaching of mathematics in the secondary schools it demands equally great changes.

We are seeing, therefore, far-reaching reform movements in the teaching of algebra and geometry, with a view to adapting these subjects to the needs of secondary school pupils. But these movements have been confined largely to improvements in the methods of instruction, or to reorganizing the traditional subject-matter within the curriculum. The problem of adapting these subjects to the needs of boys and girls of secondary schools will not be completely solved until the *content of the curriculum itself is changed in nature.* It is this development of a new content for the curriculum that the real problem movement aims at. Algebra and geometry should not be taught as so much pure science, to be put into the minds of the pupil, primarily with a view to preparation for adult life, to the total disregard of the pupil's interests and needs of the present. The subject-matter should be given a content that to the pupil is not abstract and unrelated to life, but concrete and full of human interest. It should relate strongly to, and grow out of, concrete living problems vital to the pupil—either problems encountered in his own activities or in his observation and study of the activities of the larger world. Like arithmetic as taught to-day, it should represent the mathematical element of real human experiences. It should not be completely divorced from these experiences, as it has been, *but taught in its relation to them.* The applied problems should be *real* in the sense that they are actually encountered in human experiences, and they should be *concrete* in the sense that they appeal to the actual experiences of the individual pupil.

Not only should the motive for the work find its basis largely in the attack of real problems, but every generalization, every theorem possible, every topic developed, should end in applications in the solution of real applied problems. The educative process *begins and ends with experience.* In the traditional teaching of algebra and geometry, we have practically left off the beginning and end of the educative process, and given the pupil only the middle step. We have neglected to relate the thought material to actual experience at either end.

The fundamental principle in the educative process is that of *self-activity.* Mental development comes only through self-activity of the individual pupil in solving situations that for some reason are to him concrete and vital. For education to take place there must be a problem which is *the pupil's own problem,* demanding solution. In its final analysis, education is the solving of problems that are real and vital to the pupil. For any bit of work to be educative, it must fill an actual felt need on the part of the pupil; there must be the positive conviction on the part of the pupil that the knowledge is going to function in some way in his future conduct. Here is where the old teaching of algebra and geometry has largely failed. Here is where the educational waste comes in. The study has neither been properly motivated nor assisted to function. The remedy lies in building up the subjects around real living problems that the pupil has a felt need for solving, and that are actually encountered in life and for that reason

are most apt to function in the individual's life in some way, either in doing things directly himself or in understanding the laws and processes of the larger industrial world.

Method of the Investigation.

The plan of work adopted by the committee has included (1) research by the individual members; (2) an attempt to enlist the aid of teachers of secondary mathematics generally, of men engaged in various practical pursuits, and others, in carrying on the investigation; (3) use of the columns of School Science and Mathematics for disseminating the ideas in the movement, collecting problems, and making the problem material collected accessible to all teachers of the subjects.

The members of the committee have labored individually in the attempt to find out where the applied problems of algebra and geometry are to be found, the nature of these problems, and the extent to which they are encountered in the various practical fields of activity. They have attempted to gain direct knowledge of these fields themselves—such as carpentry and the other building trades, civil engineering, bridge-building, architecture, astronomy, navigation, marine surveying, manufacturing industries, forestry, machinery, machine shop practice, designing, sheet metal work, manual training, etc. Men engaged in these fields of work have been consulted. And the literature, manuals, and scientific and trade journals that represent the various practical fields have been examined. Not only have the sources of problem material been studied, but from these sources a fund of problems has been collected.

By the general appeal through School Science and Mathematics, by circular letters, personal letters, and personal interviews, the members of the committee have tried to secure the coöperative efforts of other teachers in furnishing information along these same lines and in collecting real applied problems and contributing them to the general fund. Similar appeals have been made to men conducting the work in technical and trade schools, and in the applied science departments of some of the larger universities. Communications, including literature bearing upon the real problem movement, have been sent to a large number of individual men at work in the various trades throughout the country, asking for information and problems which they have actually encountered in their work. The attempt has been made to enlist the aid of the editors of a large number of trade journals in furnishing the committee with practical information bearing upon the investigation in the fields which those journals represent, and in printing in their columns the practical problems of algebra and geometry which their readers have encountered in their work. Some of the journals now contain such problems occasionally. The editor of the *National Builder*, Chicago, has agreed to start a problem department in which, among other things, problems encountered in the field of carpentry by the readers will be printed.

Beginning with the March number, 1909, the committee has used four pages each month of School Science and Mathematics for interesting teachers in the real problem movement and for printing the

problems that have been sent to members of the committee. All real problems sent to the committee have been printed there, where they are accessible to all teachers for class room use, and credit has been given each time to the sender. It has been hoped in this way to put into the hands of teachers, in time, a large collection of real problems for school room uses.

Results of the Investigation.

On account of the short time which the committee has had to work, no complete systematic investigation of any one field of application of algebra and geometry has been accomplished. Yet a few special fields have been rather thoroughly examined, such as carpentry, masonry, architecture, railroad surveying, designing, forestry, and some others. An exhaustive and systematic study of the various sources of problem material would consume several years, and demand the coöperative efforts of many people.

But enough has been done in a large number of fields to give some idea of the possibilities of problem material which they contain. We are convinced that the ultimate possibilities of gathering real problem material in algebra and geometry are very great. Enough has been done now, problem material enough has been collected already, *to prove that elementary algebra and geometry do have a large number of direct applications in practical life.* Among the fields which the investigation thus far has shown to be especially rich in the direct applications of algebra and geometry are carpentry, masonry, architecture, designing, surveying, railroad construction, machine shop practice, sheet metal work, forestry, physical science, and the construction and use of measuring instruments.

The problems that have been printed in School Science and Mathematics give an idea as to the nature of the applied problems that may be collected. They speak for themselves. Teachers are referred to them both for information as to what the committee has done, and as furnishing a guide in a further search for problem material. *These problems, which are to be found in the March, April, May, June, and October numbers, are to be considered as constituting in themselves a large and important part of this report.* Teachers will find accessible also a large number of applied problems in geometry printed in the *Teachers College Record*, New York, March, 1909. These were collected a year or so ago by the chairman of this committee.

In geometry three types of problems have been found, which are illustrated by the following:

(1) *Problems involving a geometrical demonstration.*

In laying out a "turnout," or switch, on a railroad track a "frog" is used at the intersection of the two rails to allow the flanges of the wheels moving on one rail to cross the other rail. The angle of the frog that must be selected for any place depends upon the central angles of the curves of the two tracks. If one track is straight and the other curved, prove that the angle f of the frog equals central angle c.

PROOF. 1. Complete the figure as shown.

2. Then angle f = angle x. (Vertical angles are equal.)

3. Angle x is measured by ½ arc AC. (Angle formed by tangent and chord.

4. OB ⊥ AC. (Radius ⊥ tangent at extremity.)

5. ∴ arc AB = arc CB = ½ arc AC. (Radius ⊥ chord bisects subtended arc.)

6. ∴ angle x is measured by arc AB.

7. But angle c is measured by arc AB. (Central angle.)

8. ∴ angle x = angle c. (Measured by same arc.)

9. ∴ angle f = angle c. (Magnitudes equal to same magnitude are equal.)

(2) *Problems involving a geometrical construction.*

(Prob. 9, May number of SCHOOL SCIENCE AND MATHEMATICS.) To draw easement of cornice tangent to rake cornice BC at B (See fig.), and passing through A.

CONSTRUCTION. 1. Draw BD ⊥ BC.

2. Draw AB, and draw EF perpendicular bisector of AB, meeting BD at O.

3. With O as center and OB as radius, draw an arc.

4. Then this arc passes through A and is tangent to BC at B.

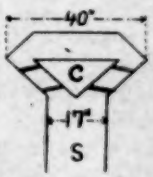
PROOF. 1. O is equidistant from A and B. (All points in perpendicular bisector of line equidistant from its extremities.)

2. ∴ the arc with center O and radius OB passes through A. (Def. circle.)

3. Since BD ⊥ BC, BC is tangent to arc AB at B. (Line ⊥ radius at extremity is tangent to circle.)

(3) *Problems involving a computation.*

(Prob. 15, April number of SCHOOL SCIENCE AND MATHEMATICS.) In a smokestack for a locomotive, find the diameter of the base of cone C so that the annular space may be equivalent to the opening of the cylindrical part of the stack S.



COMPUTATION. 1. Area of section of stack containing base of C = 400π sq. in.

2. Area of section of cylindrical part of stack = 72.25π sq. in.

3. 400π sq. in. − 72.25π sq. in. = 327.75π sq. in., area of base of C.

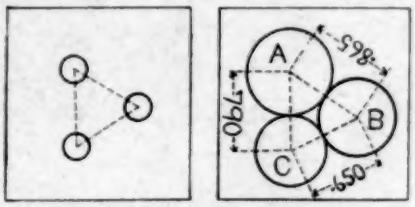
4. ∴ radius of base of C = $\sqrt{327.75}$ in. = 18.1 in.

5. ∴ diameter of base of C = 36.2 in.

In algebra two types of problems have been found, which are illustrated by the following:

(1) *Problems involving the solution of equations.*

(Prob. 15, June number of SCHOOL SCIENCE AND MATHEMATICS.) In accurate tool work where holes are to be bored close together in a metal plate by means of a lathe, the centers of the holes are first marked carefully to thousandths of an inch. This may be done by first turning discs on the lathe such that when placed tangent to each other their centers mark the positions of the centers of the required holes. These circular discs are then fastened on the metal plate in tangent positions, and the holes bored at their centers.



Three holes are to be bored, the distances between whose centers shall be 0.650 in., 0.790 in., and 0.865 in., respectively. Find the radii of the required discs.

SOLUTION. Suppose the discs placed in the positions of three tangent circles, and let their radii be x, y, and z, respectively.

Then (1) $x+y=0.650$, (2) $x+z=0.790$, (3) $y+z=0.865$.

From (1) and (2), $y-z=-0.140$.

Adding (3), $2y=0.725$.

$y=0.3625$.

Subtracting from (1), $x=0.2875$.

Subtracting this from (2), $z=0.5025$.

(2) *Problems involving evaluation of formulæ.*

The following formula is used for computing the horse power of automobile engines:

$$\text{H. P.}=KND(D-1)(R+2),$$

where K is 0.33 for racing cars, and 0.197 for commercial touring cars; N is number of cylinders; D is diameter of cylinders; and R is the ratio of the stroke (in inches) to the diameter (in inches). What will be the horse power of a 4-cylinder engine of a racing car in which the diameter is 4 in. and stroke 5 in.?

SOLUTION. Here $K = 0.33$, $N = 4$, $D = 4$, $R = 1.25$.

Substituting, H. P. $= 0.33\times4\times4(4-1)(1.25+2)=51$.

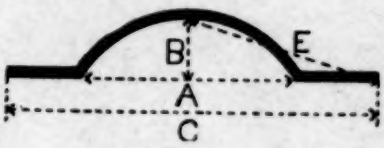
In addition to these two types of algebraic problems that are encountered in practical work, many instances are found in which equations are used in the derivation of formulæ in trade journals, manuals, etc. In general such material is not suited for secondary school pupils, because it involves a content foreign to the experiences and interests of the pupils.

Problems involving both algebra and geometry.

Many practical problems are found which involve both elementary algebra and geometry. These are illustrated by the following, a problem encountered by die-makers:

A flat circular sheet of metal is to be stamped into the form of a

spherical segment with a flange. The figure shows a cross-section of the resulting piece of metal, A being the width of the spherical part, B the depth, or altitude of the segment, and C the outer diameter of the flange. The problem is to determine the size to cut the sheet metal in order that when stamped the piece may have these dimensions.



Prove that the radius of the required flat circular sheet is equal to E, as shown in figure.

PROOF. 1. Area of spherical segment, or zone $= B \times 2\pi R$, where R is radius of sphere.

2. But $B(2R-B)=\frac{1}{4}A^2$. (Products of segments of two intersecting chords of circle are equal.)

3. Solving, $R=\dfrac{A^2+4B^2}{8B}$.

4. $\therefore$ area of segment $=B\times 2\pi\times \dfrac{A^2+4B^2}{8B}$

$$=\frac{\pi}{4}\left(A^2+4B^2\right).$$

5. Area of flange $=\dfrac{\pi}{4}\left(C^2-A^2\right)$.

6. $\therefore$ area of work $=\dfrac{\pi}{4}\left(C^2+4B^2\right)$

$$=\pi\left(\frac{C^2}{4}+B^2\right).$$

7. But this is area of circle whose radius $=\sqrt{\dfrac{C^2}{4}+B^2}$.

8. In the right triangle, $\sqrt{\dfrac{C^2}{4}+B^2}=E$.

9. $\therefore$ required radius of circular sheet $= E$.

PRINTED SOURCES OF APPLIED PROBLEMS.

The following printed sources will be found to contain or suggest many applied problems in algebra and geometry. Teachers would do well to consult as many of these sources as possible, not only to secure practical problems, but in order to become more familiar with the fields of work which they represent and to determine the general character of the mathematics encountered in those fields. They constitute a few of the sources consulted by the committee.

Books:

The Civil Engineer's Pocket-book, by Trautwine.
The Mechanical Engineer's Pocket-book, by Kent.
The Architect's and Builder's Pocket-book, by Kidder.
The Field Engineer, by Shunk, D. Van Nostrand Co., New York.
Machine Shop Calculations, by Fred H. Colvin, Hill Pub. Co., New York.
The Drafting of Cams, by Louis Rouillion, The N. W. Henly Pub. Co., New York.

Turning and Boring Tapers, by Colvin, The N. W. Henly Pub. Co., New York.

Engine Tests and Boiler Efficiencies, by Buchetti, The N. W. Henly Pub. Co., New York.

Safety Valves, etc., by Le Varr, The N. W. Henly Pub. Co., New York.

Arithmetic of Electricity, by Sloan, The N. W. Henly Pub. Co., New York.

Dies, Their Construction and Use, etc., by Woodworth, The N. W. Henly Pub Co., New York.

Electricians' Hand Book, by Sloan, The N. W. Henly Pub. Co., New York.

Builder's Guide, by Hicks, David Williams Co., 14-16 Park Place, New York.

Mensuration for Sheet Metal Workers, by Neubecker, David Williams Co., 14-16 Park Place, New York.

Educational and Industrial Drawing, by Thompson, D. C. Heath & Co.

Mechanical Drawing, by Faunce.

Constructive Drawing (Geom. Constructions), by Hanstein, Keuffel Esser Co., Chicago.

The Steel Square Pocket-book, by Stoddard, Industrial Pub. Co., New York.

The Steel Square as a Calculating Machine, by Fair, Industrial Pub. Co., New York.

New York Trade School's Text-book, by Neubecker, New York Trade School.

The Carpenter's Friend, Carpenter's Friend Co., San Francisco, Cal.

American House Carpenter, by Hatfield, John Wiley & Sons, New York.

Forest Mensuration, by Graves, John Wiley & Sons, New York.

The Building Mechanic's Ready Reference, by Richey, John Wiley & Sons, New York.

Manual of Carpentry and Joinery, by Riley, Macmillan Co.

Forest Utilization, Mensuration, etc., by C. A. Schenck, Bitmore, N. C.

Laying Out for Boiler Makers and Sheet Metal Workers, The Boiler Maker, New York.

Data Sheets from "Machinery," Industrial Press, 49 Lafayette St., New York.

"Machinery's" Reference Series (Several practical pamphlets), Industrial Press, 49 Lafayette St., New York.

Modern Sheet Metal Workers' Instructor, by Rose, F. J. Drake Co., Chicago.

Sheet Metal Workers' Instructor, by Warn & Horner, C. Lockwood & Son, London.

Complete Modern Carpentry and Joinery, by Hodgson.

Hand-book of Ornament, by F. S. Meyer.

Accounts, by W. M. Cole.

Text-book of Institute of Actuaries (English), two vols.

Aufgaben-Sammlung aus der Arithmetik, Geometrie, und Trigonometrie, by Schuelke.

Aufgaben-Sammlung, nebst Anwendungen auf das Bürgerliche Leben, Geometrie, und Physik, by Schuelke.

Lehrbuch der Mathematik nach Modernen Grundsaetzen, by Behrendsen-Goetting.

Trade Journals:

American Machinist, 505 Pearl St., New York.
Machinery, 49-55 Lafayette St., New York.
The National Builder, Chicago.
Carpentry and Building, 14-16 Park Place, New York.
The National Engineer, Chicago.
Modern Machinery, Chicago.
Power and the Engineer, 505 Pearl St., New York.
Railway and Locomotive Engineering, 114 Liberty St., New York.
Railway Master Mechanic, Chicago.
The Engineer, London.
American Carpenter and Builder.
Official Gazette, U. S. Patent Office.
The Metal Worker, 14-16 Park Ave., New York.
Cement and Engineering News, 22 Fifth Ave., Chicago.
The Chemical Engineer, 355 Dearborn St., Chicago.
The Iron Age, 14-16 Park Place, New York.
The Boiler Maker, 17 Battery Place, New York.
Practical Engineer, 355 Dearborn St., Chicago.
Brick, 45 Plymouth Court, Chicago.
The Electrical Age, 45 E. 42nd St., New York.
Electrical World, 239 W. 39th St., New York.

Adaptation of Problems to School Uses.

Of the many real applied problems of elementary algebra and geometry that are encountered in the various practical fields of work, not all are adapted to the uses of the secondary school. Some are too complicated. And many involve a knowledge of technical matter that is foreign to the experiences and interests of secondary school pupils. These belong more properly to the work of the technical school. It is a question as to how far the non-technical high school may make use of this material.

The problem is (1) to collect the real problem material, and (2) to determine by its use in the school room its adaptability for secondary school work. We need, therefore, to continue to search for problem material that is encountered in actual life. But we must follow this up by systematic experimentation, not in just a few schools, with a view to determining what part of the material that has been collected appeals to the interests and experiences of boys and girls in the high schools. Some of the material offered will be found unsuited and must be discarded, but only by trying it out in the school room will this be accurately determined. For example, it may be found that problems in carpentry will appeal to pupils, but that problems in railroad surveying will possess no interest. Problems encountered by the stone mason may relate to the apperceptive mass of the pupil, while problems in marine surveying may be Greek to him. Again, it may be found that the problems of a certain field will be intensely interesting to boys, but not appeal to girls. Hence, it might be found advisable

to teach boys and girls in separate classes, on account of their different interests in the problem material.

The committee urges that teachers coöperate in prosecuting this phase of the investigation. It is urgent that a large number of schools try using the real problems that have been printed in the *Teachers' College Record* and in SCHOOL SCIENCE AND MATHEMATICS, and that it is hoped will be collected and printed in the future, with a view to determining what the fields are in which the problems are best adapted to the interests and experiences of secondary school pupils, whether the interests and knowledge of boys and girls relative to the problem material are different, and just how, and the extent to which supplementary explanation on the part of the teacher is necessary in presenting the problems, etc. It is assumed that teachers will exercise care in presenting the problems in order to make the experiment fair. Some sort of report based upon such experimentation with the problem material should be of great value.

THE CURRICULUM AND THE REAL PROBLEM MATERIAL.

The investigation of the various practical fields where elementary algebra and geometry are used should result in a redistribution of values in the subjects. The relative usefulness of the different parts of the subjects where they are applied in life should determine to some extent their relative values in the secondary school course. Certain topics which find few or no applications in practical work should be given less prominence in the secondary school, where the great majority of students will never have occasion to pursue more advanced courses in mathematics, and will leave the secondary school directly to enter upon some practical vocation.

The actual applications of algebra and geometry should furnish thus a true basis for the elimination and choice of subject-matter in the curriculum.

Since in the practical fields of application many of the problems encountered involve both algebra and geometry, if these subjects are taught more in relation to their actual uses, a degree of correlation of algebra and geometry will be secured through the nature of the problem material. That unification of the different subjects of mathematics in the secondary schools is most natural which is found in their uses in practical life.

It is evident also that this movement to teach algebra and geometry more in relation to their direct uses in practical life should in time help determine the organization and sequence of the subject-matter within the curriculum.

JAMES F. MILLIS, *Chairman, Francis W. Parker School, Chicago, Ill.*
Jos. V. COLLINS, *State Normal School, Stevens Point, Wis.*
C. I. PALMER, *Armour Institute of Technology, Chicago, Ill.*
E. FISKE ALLEN, *Teachers College, New York, N. Y.*
A. A. DODD, *Manual Training High School, Kansas City, Mo.*

EDITOR'S NOTICE.

Owing to an increase in imperative duties Professor Ira M. DeLong, who has been connected with the Problem Department from its beginning, has been compelled to resign from its editorship. The management of the magazine was very loath to have him do this as under his skillful direction this part of our work was meeting with unqualified success. He was ably assisted by Dr. Saul Epstein of the mathematics faculty of the University of Colorado.

We have been particularly fortunate in prevailing upon Dr. Elmer L. Brown, Principal of the North Side High School, Denver, to assume control of this department. We feel sure that there will be no diminution in the high character of the work which has been done here. All communications relating to this department should be sent to the editor at the address given below.

PROBLEM DEPARTMENT.

E. L. BROWN,

Principal North Side High School, Denver, Colo.

Readers of the magazine are invited to send solutions of the problems in this department, and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

161. *Proposed by John Gaub, Ithaca, N. Y.*

The diameters of the ends of a 24-foot log are 3 and 4 feet. How far from the larger end must it be cut so that it shall be divided in half?

I. *Solution by F. R. Ritzman, Buda, Ill.*

Let x = altitude of part of cone above frustum.

Then $x+24 : x = 4 : 3$, whence $x = 72$.

Volume of log $= 74\pi$.

Volume of cone whose altitude is $72 = 54\pi$.

Volume of cone above cut in log is $\frac{74\pi}{2} + 54\pi = 91\pi$. Let y equal altitude of this cone.

Then $91\pi : 54\pi = y^3 : 72^3$, whence $y = 85.68$.

Number of feet of cut from larger end is $(72+24) - 85.86 = 10.32$.

II. *Solution by G. B. M. Zerr, Philadelphia, Pa.*

Let D=diameter of larger end,

d=diameter of smaller end,

l=length,

x=distance of section from larger end,

y=diameter of the section.

Then $\frac{1}{12}\pi x\,(D^2+y^2+Dy) = \frac{1}{24}\pi l\,(D^2+d^2+Dd)$

But $y = D - \frac{x}{l}(D-d)$

$\therefore\ 2x^3\ (D-d)^2 - 6Dlx^2\ (D-d) + 6D^2l^2x = l^3\ (D^2+d^2+Dd)$.

Putting $D=4$, $d=3$, and $l=24$,

$x^3 - 288x^2 + 27648x - 255744 = 0$;

$\therefore x = 10.3196$ feet.

162. *Proposed by H. E. Cobb, Chicago, Ill.*

When the equations (1) $x = y - z + 2$

(2) $x - z : y + z = 1 : 2$

$$(3)\quad \frac{x-2}{4y-4} = \frac{1}{2} + \frac{z-1}{y-1}$$

are solved by the usual method, the result is $x=2$, $y=1$, $z=1$. The same result will be obtained if in (3) ½ is replaced by any positive or negative, integral or fractional number, except 0. If ½ is replaced by 0 the problem is indeterminate. If from (1) and (2) one finds $x = 4z-2$ and $y = 5z-4$, and substitute these values in (3) z disappears, and he has $\frac{1}{8} = \frac{1}{2} + \frac{1}{8}$, a contradiction. Where lies the error?

I. *Solution by H. E. Trefethen, Kent's Hill, Maine.*

The contradictory result is obtained by removing the zero factor $z-1$ from equation (3) after substituting the values of x and y (for any factor containing the unknown quantity=0).

If we put k in the place of ½ and substitute for x and y, the form $k(z-1)=0$, to which (3) properly reduces, explains the anomalies. For k may be any finite number whatever without changing the values of x, y, and z, since $z-1$ remains=0. But if $k=0$, then $z-1 = \frac{0}{0}$, (3) is not an equation of condition and hence the other two are indeterminate.

II. *Solution by A. M. Harding, Fayetteville, Ark.*

If $x=2$, $y=1$, $z=1$ equation (3) takes the form $\frac{0}{0} = \frac{1}{2} + \frac{0}{0}$.

Since $\frac{0}{0}$ is indeterminate this equation will be true when ½ is replaced by any positive or negative, integral or fractional number. If, however, we put 0 in place of ½, equation (3) reduces to equation (1), and the problem becomes indeterminate. If in (3) we substitute $x = 4z-2$, $y=5z-4$ we have $\frac{(k-1)}{5(k-1)} = \frac{1}{2} + \frac{(k-1)}{5(k-1)}$.

This becomes $\frac{1}{5} \cdot \frac{0}{0} = \frac{1}{2} + \frac{1}{5} \cdot \frac{0}{0}$. Since $\frac{0}{0}$ is not necessarily equal to unity, this will not take the form $\frac{1}{5} = \frac{1}{2} + \frac{1}{5}$.

Remark by the Proposer.

This problem shows the necessity of verifying solutions of equations by substituting the values obtained in each of the given equations. In clearing of roots and radicals new values may be introduced which are not solutions of the given equations.

Geometry.

163. *Proposed by G. E. Congdon, Hiawatha, Kansas.*

Given the trapezoid ABCD having AB equal to one half the parallel

side CD, and K the middle point of BD. To prove the sides of the triangle AKC are equal respectively to the medians of the triangle BCD.

Solution by A. Dawkins, Ashland, Oregon.

Let F be the midpoint of CB, and E the midpoint of CD.

Then ABCE and ABED are parallelograms.

CK, the median to BD is identical with the side CK.

BE, the median to CD, is equal to the side AC.

Since AE equals and is parallel to BD, and since AF=½AE and KD =½BD, therefore AKFD is a parallelogram, and FD, the median to CB, is equal to the side AK.

164. *Proposed by T. M. Blakslee, Ames, Iowa.*

The joins of the opposite vertices of a hexagon circumscribed about a circle are concurrent.

I. *Professor Langley's proof, submitted by the proposer.*

Langley's Theorems.

I. All points whose distances from two intersecting rays are in a given ratio are collinear.

II. If three rays l, m, n, through the vertices of a triangle ABC have the distance ratios $b':c'$, $c':a'$, and $a':b'$ from the respective sides, l, m, and n are concurrent.

III. If through the point of contact of a ray and a circle a diameter and a chord be drawn, and a perpendicular be let fall from any point in the tangent upon the chord, the tangent and diameter have the same ratio as the perpendicular and chord.

IV. The ratio of the distances of the join of two tangents from two chords through the contact points is the same as that of the corresponding chords. (By III.)

Proof of theorem—Let (A, A'), (B, B'), and (C, C') be the three pairs of opposite vertices; also a, b, and c the joins of the contact points of BC and B'C', AC' and A'C, AB and A'B'.

By IV A and A' have the distance ratio $b:c$ from b and c.

By I all points of AA' have this distance ratio from these lines, and conversely; similarly for BB' and CC'.

Hence, AA' contains L, the join of b and c,

BB' contains M, the join of c and a,

CC' contains N, the join of a and b.

Applying II to triangle LMN, AA', BB' and CC' are concurrent.

II. *Solution by E. H. Myers, McKeesport, Pa.*

Let ABCDEF be any circumscribed hexagon and a, b, c, d, e, f the sides of the inscribed hexagon, A being the pole of a, etc. Let a and d intersect in L, b and e in M, c and f in N. The intersections of the three pairs of opposite sides of the inscribed hexagon are, by Pascal's Theorem, collinear; hence L, M, N lie in a straight line. Therefore their polars AD, BE, CF are concurrent.

III. *Solution by H. E. Trefethen, Kent's Hill, Maine.*

Let ABCDEF be any circumscribed hexagon and the fixed tangents AB, BC, DE, FA meet CD in H, C, D, P and EF in K, Q, E, F. Then (HCDP)=(KQEF); for four fixed tangents cut any other in points whose anharmonic ratio is constant. Also (A—HCDP)=(B—KQEF). These two pencils have equal anharmonic ratios and of the four pairs

of homologous rays AH—BK coincide, AC—BQ meet at C, AD—BE at O, AP—BF at F. Hence COF is a straight line and AD, BE, CF meet at O.

Trigonometry.

165. *Proposed by G. B. M. Zerr, Philadelphia, Pa.*

I measure a distance AD=300 yards. The angle BAC=the angle CAD =30 degrees. The angle ADB=45 degrees and the angle BDC=67½ degrees. Find BC without using tables.

Solution by H. E. Trefethen, Kent's Hill, Maine.

Let AC intersect BD at O. Bisect BO at E. On AC take AF=AD.

Then $AE = AD \sin 45^\circ = 150\sqrt{2}$.

$AB = c = AE \sec 15^\circ = 300(\sqrt{3} - 1)$.

$FC = FD = 2\,AD \sin 15^\circ = 150(\sqrt{6} - \sqrt{2})$.

$AC = b = AF + FC = 150(2 + \sqrt{6} - \sqrt{2})$.

$\therefore\ a^2 = b^2 + c^2 - 2bc \cos 30^\circ = 90000(4 - \sqrt{6} - 2\sqrt{3} + 2\sqrt{2})$.

Whence a=BC=286.941 yards.

BC may also be found from either of the triangles BDC or BOC.

Credit for Solutions Received.

Algebra 155. H. E. Trefethen. (1)

Geometry 156. H. E. Trefethen. (1)

Geometry 157. H. G. McCann, O. R. Sheldon, H. E. Trefethen. (3)

Geometry 158. H. E. Trefethen. (1)

Miscellaneous 159. Two incorrect solutions. (2)

Applied Mathematics 160. O. R. Sheldon, H. E. Trefethen. (2)

Algebra 161. T. M. Blakslee, W. B. Borgers, Mary E. Caster, A. M. Harding, D. L. Hines, H. G. McCann, F. R. Ritzman, O. R. Sheldon, H. E. Trefethen, C. B. Tremper, G. B. M. Zerr. Also one incorrect solution. (12)

Algebra 162. T. M. Blakslee, H. E. Cobb, A. M. Harding, D. L. Hines, H. E. Trefethen, G. B. M. Zerr. (6)

Geometry 163. W. B. Borgers, G. E. Congdon, M. L. Constable, A. Dawkins, A. M. Harding, D. L. Hines, O. R. Sheldon, H. E. Trefethen, C. B. Tremper, G. B. M. Zerr. (10)

Geometry 164. T. M. Blakslee, M. L. Constable, E. H. Myers, H. E. Trefethen (2 solutions), G. B. M. Zerr. (6)

Trigonometry 165. T. M. Blakslee (2 solutions), W. B. Borgers, O. R. Sheldon, H. E. Trefethen, G. B. M. Zerr. (6).

Total number of solutions, 50.

PROBLEMS FOR SOLUTION.

Algebra.

172. *Proposed by W. T. Brewer, Quincy, Ill.*

Find three square numbers which form an arithmetical progression.

173. *Proposed by Orville Price, Denver, Colo.*

In how many ways can 10 red flowers and 5 white ones be planted around a circular plot so that two and only two red ones are adjacent? (From Hawkes' Advanced Algebra, p. 150.)

Geometry.

174. *Proposed by Albertus Darnell, Detroit, Mich.*

If the sides of a quadrilateral are trisected and straight lines are

drawn through the pairs of points nearest each vertex, a parellologram is formed whose diagonals intersect in the centroid of the quadrilateral.

175. *By request.*

Let PAA', PBB', PCC' be three secants to a circle, PBB' lying between the other two. Let the chords AB', A'B intersect in Q, and the chords BC', B'C intersect in R. Let M and N be the points of contact of tangents from P to the circle. Prove, *by elementary geometry*, that points M, Q, R, N are collinear.

Trigonometry.

176. *From the School Visitor, June, 1894.*

Lines run from a point, P, within a triangular piece of land to the vertices A, B and C are 91, 102, and 80 rods, respectively; and a line 78 rods in length passing through the point P and terminating in the sides AC and BC, cuts off 3,024 square rods adjacent to the vertex C. Find area of field.

Applied Mathematics.

177. *Proposed by H. C. Whitaker, Philadelphia, Pa.*

Four men are carrying a log 30 feet long, weighing 25 pounds per lineal foot, with a man weighing 150 pounds sitting on one end. Two of the men have hold of the log 5 feet from the end on which the man sits. At what point are the other two holding, provided each of the four men is carrying the same amount?

CONFERENCE OF FOREST SCHOOLS TO BE HELD IN DECEMBER.

The heads of all universities, colleges, and schools in which technical forestry is taught have been invited by Gifford Pinchot, United States Forester, to attend or send a representative to the Conference on Education in Forestry which will be held in Washington in December. In his letter of invitation, the Forester says:

"I believe that a conference of representatives of all forest schools and universities and colleges in which forestry is taught might be made of great value to the general progress of forestry in the United States, as well as to the institutions which teach forestry, and to the Forest Service, which employs so many of their graduates, and which is vitally interested in the best training of foresters. Such a conference might well consider the objects and methods of forest instruction, the organization and standards of educational work in the field of forestry, the coördination of the work of different institutions, and the needs of the Forest Service and other employers of forest graduates.

"I hope you will find it possible to be present or to send a delegate to a conference of this kind, which, with the concurrence of the institutions concerned, will be held in Washington, December 30 and 31, 1909."

From all over the country the plan has met with enthusiastic support, letters of acceptance having been received from nearly every institution to which the invitation has been sent.

THE GLACIAL HISTORY OF THE GREAT LAKES. RECENT PUBLICATIONS.

Summary of the Surface Geology of Michigan, by A. C. Lane. Michigan Geological Survey. Annual Report for 1907.

The Raised Beaches of the Cleveland, Berea, and Euclid sheets of Ohio, by Frank Carney. Vol. V part 4, of the 17th Annual Report of the Ohio State Academy of Science. 1909.

The Abandoned Shore Lines of Eastern Wisconsin, by J. W. Goldthwait. Wisconsin Geological and Natural History Survey. Bulletin No. XVII. 1907.

The Ann Arbor Folio, by Frank Leverett and others. United States Geological Survey Folio No. 155. 1908.

Teachers of physical geography in the secondary schools of the middle west, especially in those states about the Great Lakes find scant material for the class discussion of the former extension of the Great Lakes. The above publications of recent date bring to the geography classes a wealth of material in the glacial history of this region. These are largely detailed studies of the local areas, where the raised beaches are well developed, and these investigations have followed the brief but admirable summary of the glacial history of the Great Lakes by F. B. Taylor and the more extensive monographs on the various ice lobes by Frank Leverett.

In the "Abandoned Shore Lines of Wisconsin," there is an extensive summary of the investigations of the history of the Great Lakes from the time of Col. Whittlesey in Ohio, Bella Hubbard in Michigan, Hall in New York, and Lyll in Ontario. A short summary of the extinct lakes serves as a valuable introduction to the discussion of the conditions in Wisconsin. The most important contribution in this paper is the careful tracing of the beaches along the western shore of Lake Michigan and their relation to the warping or the uplifting of the land. It is shown by spirit leveling that the beach at Washington Island in Green Bay is 70 feet higher than the corresponding beach to the south at Two Rivers, Wis. Since the above results were published Goldthwait, in connection with Taylor, has traced the Algonquin beach along the eastern edge of Lake Michigan and it has been found that this beach at Mackinac Island, Mich., is over 200 feet above the same beach at the southern end of this lake. This gives some conception of the uplifting which has taken place in this region since glacial time, and its effects are seen in the form, the drainage, and the size of the present lakes.

The "Ann Arbor Folio" contains a clear description of the glacial forms in the vicinity of Ann Arbor and Ypsilanti, Michigan. The abandoned shore lines of this region are clearly shown on an excellent map and their features well described. The evolution of drainage in southern Michigan is well worked out. It is a local study in a region where there exists an unusual combination of inter-lobate moraines, ancient beach lines and level lake plain country.

In the "Summary of the Surface Geology of Michigan" is a clear geological map and a large scale surface map of the state. The latter

is in sections and could be easily mounted for a wall map which would prove valuable in local geography in any part of the state and to students outside of the state it is of worth to illustrate the looped character of the moraines and various relations between the glacial deposits and the ancient ice sheet. There is a brief discussion of the various glacial forms which is accompanied by selected examples for illustration, *i. e.*, the drumlins from the Traverse Bay region, the eskers between Jackson and Lansing, the kames at Howell, walled lake in Sanilac county, and the beach lines between Ypsilanti and Detroit. The soil, which means much to the life of a region and usually receives a slight in high school geography, is briefly discussed and its economic importance brought to the attention of the reader. The History of the Great Lakes is reviewed in clear language and well illustrated by maps so that it might form a guide for the high school student and teacher. This Summary of the Surface Geology of Michigan deserves a wide distribution in the state, and other state surveys would perform a valuable service if they would issue similar short summaries for the use of the teachers of their respective states.

In the "Raised Beaches of the Euclid, Cleveland, and Berea Sheets of Ohio," there is a discussion of the beaches of northern Ohio which is the classic ground where the investigation of the glacial lake beaches had its origin. The accompanying map of this region is a poor one, but this defect will no doubt be remedied in the forthcoming publications and the style is such that it will be easily understood by the high school student. The course traversed by each beach across the region is described in detail and special attention is given to the life relation of these ancient shore lines. The Cuyahoga River, the old delta, and the extinct beaches are considered in relation to their effect upon the growth of Cleveland.

With these publications, along with some of the pioneer works by Taylor, Leverett, and Wright, at the disposal of the teacher there is no reason why a course in physical geography should not be full of interest and of practical value. There is certainly no excuse for a droning over the archaic material when the new possesses so much of the vital.

W. M. Gregory.

CHILDREN LEARN HOW TO PREVENT CONSUMPTION.

Country Loses Millions Yearly in Wasted Education.

Over 2,500,000 of the 17,000,000 school children enrolled in the United States have during the school year just closed, been systematically instructed concerning the dangers of consumption and the methods for its cure and prevention, according to a statement issued to-day by the National Association for the Study and Prevention of Tuberculosis.

Besides the 2,500,000 children thus regularly instructed in their schools, the National Association estimates that fully 1,000,000 more have received instruction at the various tuberculosis exhibits held in all parts of the country or in separate classes and organizations.

A number of investigations conducted in various parts of the world show that a large percentage of the children in the public schools have

tuberculosis before they are eighteen. That a larger number of them do not die, is due to the fact that healthy children are able to resist the attack of the consumption germ. On account of the prevalence of the disease among children, the National Association considers their education to be of prime importance.

In Boston, a special commission which recently investigated the subject, found that over 5,000 school children in that city alone had positive cases of tuberculosis. In New York, a recent study showed over 25,000 tuberculosis children in the schools. On the basis of these and other investigations, it is estimated by certain authorities that there are nearly 1,000,000 school children in the United States to-day, who will probably die of tuberculosis before they have reached the age of eighteen. This would mean that the public schools of the country are paying annually about $7,500,000 for the education of children who will die before they reach the age of eighteen. At least one half of this sickness, and possibly three fourths of it, could be prevented, if the municipal and state governments would adopt better and more hygienic methods of controlling and teaching the children, and if the public in general were alive to the need for tuberculosis prevention.

ANOTHER INTRODUCED PLANT DISEASE.

A disease of the white pine in German forests has for some time been feared in this country. In a recent number of *Science* (August 13, 1909) Mr. Perley Spaulding reports having recently found the disease on white pine stock imported from Germany. The disease is due to the fungus *Peridermium Strobi* Klebahn, and is so destructive that if generally introduced in this country will certainly work havoc to the large number of white pine plantings so largely depended upon for the work of reforestation of much of our deforested lands. Although the disease was so recently discovered in this country it is not unlikely that it may already occur in a good many regions, and much care must be observed to prevent widespread destruction from it.

According to Mr. Spaulding it is not likely that the disease may be transmitted directly from one tree to another, but must first pass through its alternate stage which it has on several species of the currant and gooseberry genus *Ribes*. This stage of the parasite on *Ribes* has been known as *Cronartium ribicola*, from which the spores are carried which in turn produce again the disease on the pine. To destroy the disease it is recommended that the following treatment be used: "(1) to immediately burn the diseased white pine trees; (2) to inspect all neighboring currant and gooseberry bushes in August and September, and to burn any affected plant; (3) to inspect the pine trees again in April or May of next spring (1910) and burn all that are found diseased. It may be also necessary to repeat the inspection of the currant bushes in 1910."

So important is the extermination of this disease that on the twenty-eighth of June there was held in New York City a meeting of the delegates of thirteen forestry organizations, at which time was urged the greatest care in destroying the disease and in preventing its further importation.

O. W. C.

BOOKS RECEIVED.

First Principles of Chemical Theory. By C. H. Mathewson, Ph.D. First edition. 1908. Pp. 123. New York: John Wiley & Sons. Price, $1.00 net.

Laboratory Notes on Industrial Notes Analysis. A survey course for engineers. By Allen H. Richards. First edition. 1908. Pp. 49. New York: John Wiley & Sons. Price, 50 cents net.

The Fresh Water Aquarium and Its Inhabitants. A guide for the amateur aquarist. By Otto Eggeling and F. Ehrenberg. Pp. 352. 1908. New York: Henry Holt & Co. Price, $2.00 net.

Notes on the Teaching of Elementary Chemistry, with a Sequence of Experiments on Air and Combustion. A teachers' edition. By J. B. Russell, B.Sc. Pp. 104. 1907. London: John Murray, 50 A Albemarle St., W. Popular edition. Price, 2/6.

A Laboratory Course in Plant Physiology. Second edition. By W. F. Ganeng. 1908. Pp. 264. New York: Henry Holt & Co. Price, $1.75.

Physiology and Hygiene for Secondary Schools. By Francis M. Walters. Pp. 424. 1909. D. C. Heath & Co., Boston.

College Algebra. By H. L. Rietz and A. R. Crathorne. Pp. 261. 1909. Henry Holt & Co. New York. Price, $1.40 net.

The Pupils' Arithmetic, Primary Book. Part one. By J. C. Byrens and Julia Richman and John S. Roberts. Pp. 216. 1909. The Macmillan Company, New York. Price, 26 cents net.

Webster's New Standard Dictionary. Common School Edition. 1908. Pp. 750. Laird & Lee, Chicago. Price, 75 cents.

Co-ordinate Geometry. By H. B. Fine and H. D. Thompson. 1909. Pp. 300. The Macmillan Co., New York. Price, $1.60 net.

The Fundamental Principles of Chemistry. An Introduction to all Text-books of Chemistry. By Wilhelm Ostwald. 1909. Pp. 348. Longmans, Green & Co., New York. Price, $2.25.

Elements of Agriculture. By G. F. Warren. 1909. Pp. 434. The Macmillan Co., New York. Price, $1.10 net.

Webster's New International Dictionary. Editor-in-chief, Dr. W. T. Harris. 2,700 pages. 6,000 illustrations. 1909. G. & C. Merriam Co., Springfield, Mass.

BOOK REVIEWS.

Laboratory Experiments in Chemistry. By B. W. Peet, Associate Professor of Chemistry Michigan State Normal College. Fourth edition revised. Pp. 129. 1909. George Wahr, Ann Arbor, Mich.

This differs mainly from the previous editions in the excision of a few experiments, that did not give entirely satisfactory results in the hands of beginners, and the rewriting of others. One hundred four (104) experiments are devoted to the nonmetals; twelve (12) of these are quantitative. Forty-six (46) are given to the study of the metals. The appendix contains two pages of equivalents, table of atomic weights of the elements, a very complete classified list of books and periodicals for a chemical library, list of apparatus and chemicals, six pages of

directions for making reagents and solutions, three pages of general hints, directions for removing stains, etc. The experiments are well written, the questions well selected, requiring observation and thought on the part of the pupil. The book is of a more convenient size for the pocket than the former edition. It is well bound and printed on good paper. This revision is an improvement in many respects over the former edition. It is one of the two best laboratory manuals that the writer has ever examined. C. M. T.

Physical Laboratory Manual for Secondary Schools. Revised edition, 1909, by C. F. Adams. Pp. 192. American Book Company. Price, 60 cents.

This excellent manual is the result of twenty years' experience in teaching physics in one of the largest high schools in this country. There are seventy-eight experiments well proportioned as to subjects: ten being given to simple measurements; eight, to mechanics of solids; twelve, to mechanics of fluids; eight, to sound; twelve, to light; nine, to heat; twenty, to magnetism. There is an appendix with hints for the teacher and twenty tables of constants for the pupils' use.

The experiments are well selected and so written that "the number of quantitative observations in many experiments may be reduced to a minimum and the qualitative feature of the work emphasized, if the teacher desires."

The laboratory directions are so complete that the average pupil can set up the apparatus and work out an experiment with a minimum of help from the teacher.

It is the most up-to-date manual published, including several of the experiments described in the pages in SCHOOL SCIENCE AND MATHEMATICS during the past three years: for example, the Packard apparatus for uniformly accelerated motion, and measurement of the wave length of sodium light using a diffraction grating.

C. M. T.

Table of Properties of Over Fifteen Hundred Common Inorganic Substances. By Wilhelm Segerblom. Pp. 144. Exeter Book Publishing Co., Exeter, N. H. 1909.

The book describes the principal properties of the metal and thirty-five compounds of each of the twenty-four (24) metals usually studied in a course in qualitative analysis.

The grouping of the metals is that employed by Fresenius. One hundred and sixteen pages are given to these properties. The formulæ, the chemical name and the common names of the compound are given. "The properties given include state, color, luster, crystalline form, deliquescence, efflorescence, stability in air, action on test paper, melting point, behavior when heated, solubility in water, alcohol and acids, and other characteristic properties." Eight pages are given to the description of properties of thirty-five (35) of the more common acids, and a condensed statement of the properties, solubilities and reactions of the salts of each acid, taken as a class; twelve pages to the nonmetals, the metals not described in the first list, and the rare metals, the more important oxides of these elements being also included. Last, but not

least, is an index of eight pages containing the common names as well as the chemical names of each substance mentioned.

It is up-to-date, the atomic weights being taken from the report of the International Report on Atomic Weights, published in January, 1909.

This is a most unique and invaluable reference book for every chemical laboratory. A glance at its pages will answer many an inquiry that otherwise could not be answered at all without access to such a chemical laboratory as only the large colleges possess, and then only after a search through several dictionaries.

It is a condensed thesaurus of properties; every teacher of chemistry should have a copy on his table for his own and his pupils' use.

C. M. T.

Plane and Spherical Trigonometry and Tables, by William A. Granville, Ph.D., Sheffield Scientific School, Yale University. Pp. 264+38. $1.25. Ginn and Company. 1909.

At last we have a standard trigonometry in which a four-place of logarithms is used throughout. This of itself would justify the publishing of a new text-book, since in most of the ordinary engineering computations results are carried to only three or four significant figures. With these tables much time is gained for other important work in trigonometry, while the few students who need to use more extended tables can readily learn to use them.

The student is first taught to use the natural functions in the solution of simple problems involving right triangles; this will give him a clearer insight into the real meaning and use of trigonometry. Moreover, the combined ruler and protractor of celluloid which is found on the inside of the back cover, if used from the first to make careful drawings and to check numerical calculations will aid greatly in giving the student a real working knowledge of the subject. The pages are pleasing to the eye, and the figures are well drawn and illuminating. There is a lack of real applied problems, and applications in engineering.

In spherical trigonometry some simplifications have been introduced. The principle of duality serves to decrease by nearly one half the work usually required in deriving the standard formulas. The treatment of the most important applications of spherical trigonometry to geodesy, astronomy, and navigation is clearer and simpler than is the rule in elementary text-books.

H. E. C.

New Laboratory Manual of Physics, by S. E. Coleman, Oakland, California, High School. 8vo, 264 pp., cloth. American Book Co., 1908.

This "new" laboratory manual clearly indicates that its author has kept in touch with the progress that has been made in recent years in the teaching of physics.

Among a number of good points emphasized in the preface is the following: "These experiments should be regarded as a limited inquiry into facts at first hand, not as sources of adequate data for generalizations by the pupil or as 'verifications' of the laws and principles stated in the text. The pupil's experiment is not a proof of the law, but an aid to the right understanding of it."

The manual contains directions for 147 experiments carefully worked out in the following form:

(*a*) References to some ten standard texts.

(*b*) The object of the experiment.

(*c*) A list of apparatus with diagrams.

(*d*) A description of the experimental work with suggestive questions.

(*e*) A discussion, which aims to draw out the salient points of the exercise.

Several practical exercises of especial interest to boys are included, *e. g.*, a model bridge, the telephone, action of a steam engine, mechanical illustration of beats.

There is appended twelve tables of constants. It is a useful, teachable, up-to-date manual, especially adapted to classes of boys. W. E. T.

New Elementary Arithmetic, by George Wentworth. Pp. 240. 45 cents. 1909. Ginn and Company.

Complete Arithmetic, by George Wentworth and David Eugene Smith. Pp. 474. 60 cents. 1909. Ginn and Company.

The point of view from which the Elementary Arithmetic was written is indicated in the preface. "In the preparation of the elementary book the controlling notion has been that arithmetic deals primarily and essentially with number. In recent years the chief pedagogic error in teaching primary arithmetic has been over-elaboration with objects. In their anxiety to get away from the old-style arithmetic, with its almost entire lack of concrete, objective work, many authors have lost sight of the fact that at this period the child must learn, and learn thoroughly, number combinations. * * * Hence in the first book of this series, while the value of definite, concrete work is recognized, the chief aim is to ground the child in the fundamental processes of arithmetic." This plan has been consistently followed, and we find about one half of the exercises consisting of work in pure number, while the remainder are the conventional exercises dealing with apples, oranges, horses, dolls, gallons, feet, marbles, and other things with which children are supposed to be familiar. The book is not a wide departure from the old-style arithmetic, and conservative teachers will be interested in it.

The authors of the "Complete Arithmetic" feel that there is need for an arithmetic having the topical arrangement, and thoroughly modern in spirit and material. "In deciding the form and arrangement for this book the authors accept the fact that each of the two well-defined types of text-books in arithmetic has advantages. A teacher may prefer either one or the other, according to circumstances or training, and the same teacher might conceivably, in the exercise of the best pedagogic judgment, use under one set of conditions a text-book of one type, and when conditions changed employ a book of the other kind. With books of the type arranged for the recurrent treatment of topics the market is well supplied. Some of extreme books of this recurrent form are, it is true, too fragmentary in arrangement to give the pupil that feeling of mastery which is his right and his reward. But excellent books of this type, which avoid its perils and

provide all its good features, are now available." In the Complete Arithmetic there is an abundance of real, concrete problems. The business problems, interest, stocks and bonds, banking, exchange, etc., are in accord with modern business customs, and there is a chapter of vocational problems. H. E. C.

An Introduction to Practical Mathematics, by F. M. Saxelby, Battersea Polytechnic School. 12 mo, pp. 220. $0.80. Longmans, Green & Co.

In the fourteen chapters of this little book are treated the following subjects: Contracted Methods of Multiplication and Division; Use of Symbols; Mensuration of Regular Figures; The Four Fundamental Operations; Factors and Fractions; Simple Equations; The Secondary Operations, including Logarithms; Plotting of Functions; Graphic Solution of Equations; Ratio and Variation; The Trigonometric Ratios; The Right Angled Triangle; Mensuration of Irregular Figures; Rate of Increase.

As stated in the preface, the book was written as an introduction to the author's larger work on the same subject, and was intended for students of technology, especially for evening students in engineering and allied sciences. It is assumed that the student has some knowledge of arithmetic and mensuration, and it is advised that he should at the same time follow a course in practical geometry.

Of the numerous books on this subject that have appeared within the last two or three years, probably no one will more fully meet the wants of those for whom it was designed. As would be expected in a work of this kind, little attempt is made to establish rigorous principles, but rare judgment is shown in leading the students up to an intelligent comprehension of the principle which it is desired to set forth, by first presenting clearly two or three arithmetical examples. The book is replete with practical examples relating to geometry, statistics, physics, and the various branches of engineering.

Chapters 1, 5, 8, 10, and 13 will doubtless be found most helpful to American teachers of fairly well-prepared students in technical subjects. In chapter 1, contracted methods of multiplication and division, which are coming to be considered quite essential in the preparation of engineering students, are very clearly and simply presented. Further use of such methods occurs in chapters 4 and 5.

The great utility of graphic methods in the discussion of functions is well shown in Chapter 8, where a number of problems, including several arising in physics and mechanics, are elaborately treated. This is supplemented by the graphic solution of equations in Chapter 9.

Chapter 10 contains an admirable treatment of ratio and variation, and a well-chosen set of problems.

Chapter 13, dealing with the mensuration of irregular figures, contains two especially important topics, viz., Simpson's rule, of much value to the engineer, and the mean value of any variable quantity.

DUANE STUDLEY.

NOTICE

Of the 1909 meeting of the Central Association of Science and Mathematics Teachers:

The annual meeting of the Central Association of Science and Mathematics Teachers will be held at the University of Chicago on Friday and Saturday, November 26th and 27th, 1909.

Professor T. C. Chamberlin of the University of Chicago, recently returned from a study of educational conditions and institutions of the Chinese Empire, will give an address at the general meeting.

Principal James E. Armstrong of the Englewood High School, Chicago, will give the results of his observation and study of segregated classes in high school work.

Friday evening will be devoted to a report on the Relation of Elementary School Nature Study to Secondary School Science.

The sectional programs will be replete with valuable papers, reports and discussions.

Some copies of the Proceedings of the last meeting of the Association are still available. The Proceedings is a volume of 224 pages containing in full the papers presented at the meeting of November, 1908, together with reports, discussions, etc. It contains reports of the committees on the Unifying of Secondary Mathematics; on Geometry; and on Algebra.

While they last copies of the Proceedings may be obtained at 50 cents each.

Persons engaged in teaching science or mathematics, or in supervising such teaching, are eligible to membership. All such persons are invited to apply for membership. New members will be carried to January, 1911, upon the payment of dues for one year ($2.50). In addition to membership each member will receive without further cost the monthly official journal, "School Science and Mathematics," and a copy of the Proceedings for 1908.

Address all communications to the Secretary-Treasurer, Willis E. Tower, Englewood High School, Chicago, Ill.

IMPORTANT NOTICE

The attention of our patrons is called to the change in the business address of this Journal to 2059 East 72nd Place, Chicago, Ill. The editorial address remains unchanged.